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Applying Activity Theory: Instructor Design and Development Experiences with Online Distance Learning in the Electrical Apprenticeship Trades Programs

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Online Distance Learning in the Electrical Apprenticeship Trades Programs

By

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Abstract

Apprenticeship training historically has been the entry point for employment in the trades in Canada. However, with increasing shortages of qualified trades workers in Canada, it is timely to explore the affordances of online distance learning (ODL) education for this post-secondary education sector. The Internet has provided students with access to distance learning in many fields, but very little research has been conducted regarding online ODL activities for apprenticeship trades training. Thus, the benefits of ODL in electrical apprenticeship trades education remain largely experimental or anecdotal. In general, the apprenticeship trades industry has determined that learning apprenticeship trades skills requires practical, physical components, but scholars must determine whether online electrical apprenticeship trades activities meet these physical, hands-on requirements for constructing objects and assimilating skill-oriented knowledge.

To examine the impact of online technologies in ODL environments for the electrical apprenticeship trades, a case study approach was used in this research in order to understand instructors' experiences in designing, developing, and delivering electrical apprenticeship trades programs in an ODL environment. The study participants were six instructors from three different public institutions in two provinces. Each case was developed from an interview with the ODL electrical apprenticeship instructor, document analysis, and a review of online materials such as the institution's website and the program and course shells.

To analyze the data collected from the case studies, five activity theory principles were applied: the hierarchical structure of activities; the social and physical aspects of the online learning environment; the learning, cognition, and articulation of online activities; the development of online activities; and the zone of proximal development (ZPD) of online

activities.

The results from the data analysis indicated that the potential of ODL was not fully realized because of local accessibility issues as well as instructors' unfamiliarity with the technologies employed. The culture of apprenticeship trades focuses on hands-on learning of practical skills from a master, and the idea that technology can provide equivalent experiences is not yet fully accepted. But the shift is underway, with a number of institutions in Canada now offering ODL in the electrical apprenticeship trades as well as in other trades such as welding and plumbing.

The research findings would be valuable to the apprenticeship trades industry because they supported the efficacy of ODL which provided options that were anticipated to increase the number of qualified trades workers. Academic administrators would benefit as the findings would assist them with their strategic, long-term planning of ODL for the apprenticeship trades. Policy makers (typically governments, both federal and provincial) would benefit from the study as it would help to provide policy direction for apprenticeship trades education. Instructors would benefit from gaining a better understanding of the impact of changing roles and responsibilities and of what is involved in designing, developing, and delivering ODL apprenticeship trades programs.

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In addition, I express my appreciation to my immediate managers and the executive management staff within the Government of British Columbia, Ministry of Technology, Innovation and Citizens' Services for their ongoing encouragement and support.

Dedication

This dissertation is dedicated to my parents, Rose and Bill Sochowski; their gift of teaching me to work hard for my aspirations and to set my goals as high as possible has lasted a lifetime, helping me through many of life's challenges.

This work is also dedicated to Patrick Corrigan, who believed in my success and to David Morhart, who provided encouragement in the critical final stages of my disseration and defense. My success would not have been possible without their support and that of my other friends, colleagues, and extended family. Their belief in me reminded me that my personal limitations are not barriers but rather enablers.

This work is also dedicated to those important people in my life who are no longer with us, in particular my dad, who passed away several weeks before my defense. I honor his memory.

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List of Symbols, Abbreviations, Nomenclature

AATTM	Adaptive Apprenticeship Trades Training Model
AT	Activity Theory
BB	Blackboard
CAD	Computer-aided design
CBAT	Competency-based apprenticeship training
CD	Compact Disk
D2L	Design2Learn
FTE	Full Time Equivalent
HRDC	Human Resources Development Canada
ILM	Individualized learning modules
IP	Inter-Provincial
LMS	Learning Management System
ODL	Online Distance Learning
PAC	Provincial Advisory Committee
SME	Subject matter experts
TLM	The Learning Manager
TQ	Trades Qualification
VET	Vocational Education Training
VR	Virtual Reality
ZPD	Zone of Proximal Development

Chapter One: Introduction

Background of the Study

With the accessibility of the Internet across Canada, many post-secondary educational institutions have made use of it for online and/or distance learning and instruction. Taking advantage of its availability and of related digital technology, many instructors designed and developed online learning programs to meet growing demand from students and employers (Liaw, Huang, & Chen, 2007; Norman & Langhill, 2006). With continuing economic changes and increased demand for apprenticeship trades skills training, it was anticipated that online education would become an increasingly important part of apprenticeship trades training programs (Canadian Apprenticeship Forum, Forum canadien sur l'apprentissage [CAF-FCA], 2013). Online learning using digital technology has offered "today's students greater flexibility in accessing training and may encourage institutions to integrate technology into the curriculum" (Sparks, Ingram, & Phillips, 2009, p. 192). However, the online delivery of course content has not yet been widely recognized for its potential benefits in apprenticeship trades training (CAF-FCA, 2013; Norman & Langhill, 2006).

Incorporating online distance learning (ODL) into the apprenticeship trades programs offered by educational institutions not only required designers of these programs to have an understanding of best practices for the apprenticeship course design and extensive knowledge of Internet technology, but it also required instructors in the apprenticeship trades to reconsider their traditional delivery methods—those that emphasized hands-on, practical experiences—in favor of distance education and the replacement of the human interface with a technological interface.

According to Norman and Langhill (2006), best practices for the design, development, and delivery of online distance learning programs focused on five areas: (a) information transmission, (b) interaction of learners with materials, (c) animation and simulation activities, (d) remote hands-on training, and (e) the role of the instructor. It was found that "apprentices learn dexterity skills required for their trade faster when using simulation technology" (CAF-FCA, 2013, p. 14). ODL technology also had the potential to reduce student time spent in the classroom, improve access to training, and save costs both for the apprentice and employers (Industry Training Authority of British Columbia & Vancouver Community College [ITA & VCC], 2007; Norman & Langhill, 2006).

In their 2006 study, Norman and Langhill determined that there were no significant differences between apprentice outcomes in face-to-face courses compared to distance courses using innovative features such as animation and simulations. They recommended strong support for developing more flexible delivery of courses in apprenticeship trades training.

Previous research from ITA & VCC (2007) showed that outside of North America online apprenticeship trades training was still somewhat new. The focus of many research studies has been on innovation for vocational education training (VET) which included using online technology for trades training. According to the Rauner & Smith (2010), Australia was considered a leader in flexible learning modalities for apprenticeship trades training. In Germany the application of digital technology to trades training included self-regulation and cooperative learning that involved improving the structures and interfaces of VET. Rauner & Smith (2010) also noted that Hungary revised its modular and competency-based framework for trades programs to include digital technology which provided financial support for low-skilled adults. In the United Kingdom such programs were still in their infancy, but educators there were beginning to identify a need to increase the use of online systems for apprenticeship trades (ITA

& VCC, 2007).

In contrast, the United States' apprenticeship trades training system was scattered, with development and delivery dominated by private organizations (ITA & VCC, 2007). In Canada online apprenticeship trades training was not consistently available across the country. Variables included cost, program designers, and government and institutional support. In 2006, the provincial government of British Columbia identified significant costs associated with developing and maintaining online apprenticeship trades programs (Hartwig, 2007; Norman & Langhill, 2006); as a result, that government provided initial funding to start up ODL apprenticeship programs. Consequently, four apprenticeship trades training institutions participated in a province-wide initiative to design and deliver online programs for apprenticeship trades called the E-PPRENTICE online apprenticeship initiative project (BCcampus & ITA, 2011). However, when provincial funding was not renewed, only two online distance apprenticeship trades programs continued (BCcampus & ITA, 2011) which highlighted a sustainability issue for ODL apprenticeship programs. The availability of provincial government funding played a significant role in motivation for developing ODL programs. Hartwig (2007) suggested that institutions' motivation to offer online apprenticeship trade programs depended on traditional face-to-face apprenticeship trades instructors' willingness to design and develop online apprenticeship programs.

In 2009, the Southern Alberta Institute of Technology (SAIT) completed a report identifying four challenges encountered by apprenticeship programs in Alberta: (a) continued growth in the demand for qualified tradespersons, (b) meeting the changing needs of industry and employers, (c) satisfying the desire of apprentices to spend less time away from paid work, and (d) addressing accessibility and cost issues for apprentices. In 2011, a consortium of 22

Ontario community colleges was created for the purpose of reviewing the feasibility of developing and delivering online courses. Four of those colleges subsequently offered online apprenticeship training (Ontariolearn, 2011; SAIT, 2009).

Available literature and recent studies in the apprenticeship field indicated that in Canada there are a small number of apprenticeship trades offering online distance learning on a regular basis in every province. Because of the small number, further research is needed to determine what constrained and what enabled instructors and institutions in terms of offering online apprenticeship trade programs.

Purpose of the Study

According to CAF-FCA (2013), the apprenticeship community aimed to “develop a better understanding of the challenges and opportunities technology poses for apprenticeship training in Canada” (p. 2). Therefore, the purpose of this study was to investigate instructors’ design, development, and teaching experiences as they shifted their thinking about education for the electrical apprenticeship trades to allow for the incorporation of ODL. In this study both the affordances and constraints of online learning technologies which had implications for instructors who designed, developed, and taught in an ODL electrical apprenticeship trades program were explored. One of the issues was that the instructors teaching apprenticeship trades courses encountered challenges when teaching ODL as Robertson (2006) indicated. This tension could have resulted from the fact that teaching apprenticeship trades skills required practical physical components that were easily accommodated in a traditional face-to-face environment, but that were difficult to approximate in an ODL environment. Scholars needed to determine whether design, development, and delivery of online apprenticeship trades programs incorporated activities which met the physical hands-on requirements for constructing objects and assimilating skill-oriented knowledge. Literature such as Hartwig's (2007) "e-Apprenticeship: Establishing Viability of Modern Technology in Traditional Practice," the Canadian Apprenticeship Forum, Forum canadien sur l'apprentissage (2013) report on the impact of technology on apprenticeship training, and Norman's and Langhill's (2007) *Alternative Trades Training: Best Practices From Across Canada* did not detail how instructors' experiences with designing, developing, and teaching in ODL trades training programs affected learning outcomes.

The following research question guided this inquiry: How do the affordances of online distance learning technologies enable or constrain instructors who are teaching in an ODL electrical apprenticeship trade training program?

The following sub-questions were investigated:

1. How might the affordances and constraints affect the design and development of ODL apprenticeship trades training programs?
2. In what kinds of social and physical environments did online technologies integrate with these environments' requirements, tools, resources, and social and cultural rules?
3. How might ODL apprenticeship trades training programs affect competencies and could they be addressed in specific training activities?
4. How might the implementation of ODL apprenticeship trades training programs influence the design of future programs?
5. How might the development of ODL apprenticeship trades training programs affect the instructors' ability to measure student assessment and achievement levels?

Rationale for the Study

Canada has faced a severe workforce development problem due to the lack of apprenticeship training programs that were “commensurate with the perceived need for [a] skilled workforce” (Hartwig, 2007, p. 4) due to declining accessibility and the high cost of traditional face-to-face apprenticeship trades training programs. Accessibility and cost concerns were compounded by the amount of time students had to take away from their workplace while attending face-to-face, on-campus courses. ODL programs for apprenticeship trades training could help alleviate the workforce development problem. However, apprenticeship trades instructors were reluctant or unable to apply best practices to the design and development of such online programs. This could have been a significant underlying reason for the perceived slow growth of ODL in apprenticeship trades training in Canada (ITA & VCC, 2007; Norman & Langhill, 2006).

Norman & Langhill (2006) noted that “the scope of the trade itself and [the] feasibility of delivering the technical training portion through alternative means needs to be considered” (p. 58) by the institution before it implements ODL apprenticeship programs. Kopp and Burkle (2010) mentioned that traditional best practices might constrain the curriculum design and development of online programs related to other professions; moreover, Norman and Langhill (2006) suggested that within the apprenticeship trades online programs, “implementing a different delivery approach may bring staff resistance due to the significant learning curve” (p. ii) in using ODL educational technologies.

Support for ODL apprenticeship trades education in Canada was driven by the Canadian apprenticeship trades education community which includes apprenticeship instructors, members of the trades industry, workplaces, students, government, and educational institutions. The findings and recommendations from this research and the provincial and territorial governing bodies of the apprenticeship trades community could determine the implications of using ODL technology in apprenticeship trades training programs, instructional design, and alternative educational content delivery.

Assumptions

The work of Kaptelinin and Nardi (2006), Kim and Bonk (2006), and Norman and Langhill (2006) indicated that program design affected the type of technology used in an online environment including the role for instructors designing and using available technologies. These scholars also mentioned that educational outcomes were affected by the type of technology used, particularly in the apprenticeship trades which predominantly focused on physical skills. An overview of the key assumptions underlying this study is provided in Table 1-1.

Table 1-1

Assumptions

	Assumption	Source
A1	Well-designed training programs, including ODL apprenticeship trades training programs can be rich in affordances associated with the ever-evolving uses of technology.	Kaptelinin & Nardi, 2006
A2	ODL apprenticeship trades instructors must meet the demand for more flexible learning and training options in the curriculum and employ different types of technology.	Kim & Bonk, 2006; Norman & Langhill, 2006
A3	ODL instructors not only teach the physical skills associated with a craft but also develop the cognitive skills normally associated with conventional schooling. Therefore, a well design ODL apprenticeship program will need to overcome the limitations of technologies.	Collins, Brown, & Newman, 1989; Hay & Barab, 2001; Lave, 1988; Lave & Wenger, 1991; Norman & Langhill, 2006; Seely Brown, Collins, & Duguid, 1989

Definitions of Terms

For the purposes of this study, the major terms are defined in Table 1-2.

Table 1-2

Definition of Terms

Term	Definition	Source
Activity Theory	Analyzes the interaction among people, culture, history, and life experiences and explores how these backgrounds influence the way people communicate and otherwise use and understand human engagement through digital technologies. It also provides a framework to examine consciousness (the human mind) and activity (human interaction with objects), which involves people acting with technology.	Jonassen & Rohrer-Murphy, 1999; Kaptelinin & Nardi, 1996; Nardi, 2006
Affordance	The actionable (or perceived) properties and relationships between individuals and objects; it refers to what individuals can do with objects and can be restricted to internal or external influences such as physical characteristics, individual behaviors while solving problems, and beliefs that might influence the creation (or constraint) of online technologies.	Gibson, 1979; Kaptelinin & Nardi, 2006; Norman, 1988
Apprenticeship Trades	A form of post-secondary education that involves a teaching approach in which students learn a trade through hands-on experience while receiving technical training in a classroom or shop setting.	ITA, 2011c; Nova Scotia Apprenticeship, 2011
Blended Learning	Enhances traditional face-to-face oral communication in a classroom with the goal of improving online communication engagement across the Internet. It offers text-based communication, creates a unique fusion of synchronous and asynchronous, and provides opportunities for "replacing aspects of face-to-face learning with appropriate online learning experiences, such as labs, simulations, tutorials, and assessments" (p.6).	Garrison and Vaughan , 2008

Term	Definition	Source
Community	The environment in which the activity is carried out and in which individuals are interacting. It may include field trips, home, school, classrooms, and computers.	Kaptelinin & Nardi, 2006; Mwanza & Engeström ,2003
Constructivism	A philosophy of education and a cognitive learning theory that assumes that meaning-making within the individual mind is developed from an interaction among individual experiences, social interactions, and ideas.	Crotty, 2004; Jonassen & Rohrer-Murphy, 1999
Constructionism	A philosophy of education and a learning theory that describes knowledge as constructed (not created) through interactions with the environment developed within a social context.	Crotty, 2004; Hay & Barab, 2001; Jonassen & Rohrer-Murphy, 1999
Distance Learning	Primary means of course delivery and a term can be used to describe a wide array of applications of electronic technologies with a special emphasis on learning through the Internet. Students and instructors interact with each other and conduct class activities via the Internet using chat, video conferencing, e-mail, and learning management systems.	Grui-Rosenblit & Gros, 2011; Liaw, Huang, & Chen, 2008; Government of Alberta, 2011a; ITA & VCC, 2007; Joy, 2004
Flexible Learning	Distance education involving a range of learning modes or methods to give learners options in the delivery of training such as when, where, and how they learn.	Collis & Moonen, 2001; ITA & VCC, 2007
Nontraditional Student	Primarily older students who enter apprenticeship trades programs after a considerable break from any form of formal education.	Dearnley, Dunn, & Watson, 2006
Online Distance Apprenticeship Trades Activity	An activity within an online distance apprenticeship trades program that includes tasks to construct objects to support learning in a distance learning environment (i.e., simulation and virtual reality).	

Term	Definition	Source
Traditional Student	Students who have recently completed high school or recent college graduates who have never been employed in their selected professions.	Dearnley, Dunn, & Watson, 2006

What the Researcher Brought to the Study

As the researcher, I brought 20 years of experience in the trades, engineering design, program development, teaching, and collaborative relationship building. I designed, developed, and taught trades courses in the post-secondary education system which afforded me the opportunity to view the education system from that perspective. My unique educational and industry perspectives gave me the ability to bridge learners' educational needs to the specific skills required in applied settings, standards to educational institutions, and government to industry. In addition, I had significant experiences as a student in distance learning having taken trade webinar courses to complete an Adult Education degree and a Master's degree by distance.

Organization of the Study

In the first chapter, the background and context for the use of online learning technologies by instructors in ODL environments for electrical apprenticeship trades training programs was presented and the relevance of the research and rationale for the study was established. Chapter Two was a review of the relevant literature surrounding online technologies, apprenticeship trades, and activity theory. The focus of Chapter Three was the research design and methodology including the design of the instrument, selection of the sample, data collection, and data analysis. In Chapters Four and Five, the study's findings were presented, and in Chapter Six those findings and implications were discussed. Chapter Seven comprised the recommendations and conclusion.

Chapter Two: Literature Review

The purpose of the literature review was to investigate research related to apprenticeship trades education in online distance learning (ODL) environments. In this section, ODL was defined and information was provided on apprenticeship trades, apprenticeship trades instruction, and various aspects of apprenticeship trades education including the characteristics of apprenticeship trades training, the need for flexible apprenticeship trades training, and best practices for online distance apprenticeship programs. The literature review section also included a definition of affordances and a description of the application of activity theory to ODL apprenticeship trades programs. The section concluded with an activity theory-based framework that presented a conceptual link between the research questions and the activity theory model.

Definition of Online Distance Learning

Before attempting to describe apprenticeship trades education delivered in an ODL environment, it was necessary to define distance and online learning. According to CAF-FCA (2013), distance-based learning for apprenticeship trades training was "remotely and computer-based learning brought about by course content delivered outside of a regular classroom" (CAF-FCA, 2013, p.18). Joy (2007) described online learning as learning for which the "means of course delivery and interaction for the class are accomplished via connection to the Internet" (p. 11). However, Grui-Rosenblit and Gros (2011) argued that online learning included a wide array of applications of electronic technologies with a special emphasis on learning through the Internet. Therefore, there was a misconception about online learning and distance education (Grui-Rosenblit & Gros, 2011). These two terms were not interchangeable: "distance learning can exist without online learning, and online learning is not necessarily distance learning"

(Bates, p. 14, 2005). The definition for distance education was “the physical separation of the learner from the instructor” (Grui-Rosenblit & Gros, 2011, p. 3).

Blended programs such as apprenticeship trades training combined both face-to-face and distance teaching methods (Grui-Rosenblit & Gros, 2011). In apprenticeship training, this delivery method included combining “online delivery with in-school training. Typically the theory portion of training was covered by the online training while the in-school training focused on the lab or shop” (CAF-FCA, 2013, p.19). For the purpose of this research, “online” was the means for theory course delivery occurring outside of face-to-face theory classrooms primarily via the Internet and the “distance” was the physical separation of the apprentice from the instructor and school. With online learning, students and instructors interacted through both synchronous and asynchronous communication to support class activities, interact with one another, engage in activities, and access learning resources.

Characteristics of Apprenticeship Trades Training

According to Davies (1956), the traditional apprenticeship-style training system predated the 1600s. Skills were passed on through a master–apprentice system in which the apprentice had a contract with the master for a specific period of years. During that time the apprentice often received basic essentials such as food, clothing, and shelter in lieu of pay. Davies further explained that the modern apprentice’s situation differed from that of the apprentice in the 1600s in that the apprentice no longer lived in the master’s house, was not dependent upon the master for basic essentials, and received pay.

Apprenticeship trades training was best described as the process by which “a more experienced person assists a less experienced one by way of demonstration, support and examples” (Dennen & Burner, 2008, p. 425). The more experienced person (master journeyperson) "[attached] primary importance to the practical skills and the dexterity skills of tradespersons, and . . . [expected] the apprenticeship systems to focus on these skills rather than on theoretical skills" (CAF-FCA, 2013, p. 11). Although apprenticeships typically enhanced psychomotor skills, Dennen and Burner (2008) pointed out that apprenticeship learning also involved a cognitive focus that was not strictly limited to psychomotor skills. This cognitive apprenticeship involved "learning that occurs as experts and novices interact socially while focused on completing a task" (Dennen, 2003, p. 813). Collins et al. (1989) described cognitive apprenticeship as "learning-through-guided-experience on cognitive and metacognitive, rather than physical, skills and processes" (p. 456).

Cognitive apprenticeship methods attempted to apply theory to practice through a combination of activities and social interaction (Seely Brown et al., 1989). Cognitive apprenticeships allowed masters to model activities in real-world contexts during which apprentices listened and explained what they were doing and thinking while performing the skill or task. Vygotsky's (1978) theory about learning occurring in a social context demonstrated how learning by doing—similar to apprenticeship trades training—created learning environments conducive to acquiring complex skills by applying both cognitive and psychomotor skills training.

Seely Brown et al. (1989) asserted that knowing and doing were equally necessary in an apprenticeship program and concluded that "the physical skills usually associated with apprenticeship embody important cognitive skills" (p. 39). They recognized that individuals often learned professions (law, medicine, business, etc.) through an apprenticeship process and highlighted the importance of cognitive content in apprenticeship training. They stated that medical education appeared to share similar curriculum design and development strategies with apprenticeship trades training in that apprenticeship trades training included master/apprentice relationships similar to those between physicians and interns. Medicine and general trades relied heavily on practical activities during training and maintained a balance between psychomotor skill development, factual knowledge assimilation, and problem-solving skill development. Similarly, studies showed that traditional apprenticeship trades training programs in Canada were comprised of approximately 80% training in the workplace while the remaining 20% included theoretical and technical lab training at technical institutes or colleges (ITA, 2011c; Saskatchewan Apprenticeship and Trades Certification Commission, 2011).

Traditional apprenticeship trades training frameworks in Canada included three stages of learning development. The first stage (approximately two to five years in duration) involved completion of classroom training and informal training, the latter usually occurring in a workplace or noninstitutional setting (Bransford et al., 2006). The second stage was classroom training, which normally included 8 to 12 weeks per year of campus block sections devoted to formal training, with some time spent in the classroom for theory components and laboratory practical skill components. The second stage included having students write their final trades qualification (TQ) exam, the completion of which bestowed on them Red Seal journeyperson certification which allowed them to practice their skills in any Canadian province or territory (Canadian Council on Learning, 2009; Red Seal, 2011). The third stage occurred when the apprentice became a master, which meant that he or she could train new apprentices (Canadian Council on Learning, 2009; Red Seal, 2011). The design and delivery of traditional apprenticeship programs in Canada had to meet provincial regulations and policies which also governed the performance of activities delivered or performed online.

Because the traditional apprenticeship model addressed psychomotor skills training in both the classroom and workplace, designers and developers of online learning for the apprenticeship trades "cannot eliminate the need for in-school instruction altogether because the trades, by their nature, require 'hands-on' learning" (CAF-FCA, 2013, p. 22). Therefore, hands-on learning may be taught by the employer or within a formal school laboratory.

The Need for Flexible Apprenticeship Trades Training

Boothby and Drewes (2006) found gaps in the literature on apprenticeship trades education and underscored the need for more research to gain deeper insight into the shortage of skilled trades people. They stated that the labor supply for apprenticeship trades education was important to the Canadian economy; the shortage of skilled trades people had become critical in some foundational vocations such as plumbing, electrical, and welding that were vital to local communities.

One reason for the shortage was that the nature of the skilled trades was changing: the "skilled trades workplaces are becoming increasingly reliant on technology, with new equipment and systems that require . . . enhanced digital skills" (CAF-FCA, 2013, p. 2). The CAF-FCA bulletin also reported that "in some trades, apprentices will need more advanced skills in order to keep up with emerging technologies" (p. 5). However, despite recognition of the need for retraining in the apprenticeship trades (Canadian Council on Learning, 2009), access to traditional training programs was denied to many apprentices. Research conducted by ITA and VCC (2007) supported a compelling need for more flexible delivery of apprenticeship trades training in Canada "for demographic, cost effectiveness and labor supply reasons" (p. 33). Hartwig (2007) noted the high demand for flexible apprenticeship trades training and asserted that its causes were the cost of training, the shortage of postsecondary seats in trades courses, and the changing workforce.

Research conducted by the Canadian government supported Hartwig's (2007) finding that the high costs of training limited access, thereby partially causing the shortage in skilled trades people and the high demand for flexible apprenticeship trades training (Canadian Council on Learning, 2009). In response, the 2009 federal government's tax system provided financial incentives for apprenticeship trades education (Canadian Council on Learning, 2009) which helped increase student enrollment in trades programs. Financial incentives alone, however, were not guaranteed to increase access to apprenticeship trades training.

Apprenticeship trades programs generally offered a limited number of student seats because the traditional educational model delivered such training in fixed locations (Hartwig, 2007). Unfortunately, financial constraints prevented schools from making improvements to physical infrastructure (building capacity, parking spaces, and training locations) that would have allowed them to accommodate increased student enrollment in these trade programs (Hartwig, 2007).

Recent apprentices demanded more flexible learning and training options (Sparks et al., 2009). Students expected instructors to incorporate new digital technologies such as "electronic books, simulations, text messaging, podcasting, wikis, and blogs" into the curriculum (Kim & Bonk, 2006, p. 22). As well, traditional programs were designed to cater to younger students who did not have the life commitments common to adult learners such as jobs, families, and mortgages; older students' lifestyles and commitments limited their availability for training (Dearnley et al., 2006; Hartwig, 2007; Sparks et al., 2009). As a result, apprenticeship trades programs were "experimenting with new technologies to improve knowledge transfer and retention, responding to industry demand and new approaches to engaging students in the classroom" (CAF-FCA, 2013, p. 2). These new approaches provided flexible training options for the current student population.

Best Practices for Online Distance Apprenticeship Trades Programs

As ODL became more common in post secondary education programs, instructors grew increasingly conscious of their role in redesigning traditional programs, including online apprenticeship trades programs (Hartwig, 2007; Liaw et al., 2007). As part of the redesign process ODL apprenticeship trades instructors were faced with challenges in designing activities based on real-world problems (Myers, 2003). Such challenges included “increasing the amount of theoretical knowledge that a journeyperson needs when maintaining machinery and equipment that uses advanced manufacturing technologies” (CAF-FCA, 2013, p. 11).

According to ITA and VCC (2007), there was strong evidence that when a well-designed and properly funded online learning apprenticeship trades training program employed best practices, the program brought measurable benefits. Best practice principles included: (a) information transmission, (b) student and material interaction, (c) animations and simulations, (d) remote hands-on training, and (e) role of the instructor.

Information transmission. Learning management system (LMS) software was used to transmit and manage the administrative aspects of course delivery, including registration, student recordkeeping, instructor management, and resources. The LMS also was used to test apprentices’ understanding of the information presented in a collaborative online learning environment (CAF-FCA, 2013; ITA & VCC, 2007). Furthermore, an ODL apprenticeship trades program provided learners with access to an interactive learning environment tailored to learners’ needs via a software application that “automates the administration, tracking, and reporting of training events” (Ellis, 2009, p. 1).

According to Abdous (2013), a LMS offered a number of benefits: “(1) in managing the administrative process surrounding course management, particularly regarding student enrollment and access to content and grades; (2) in storing, processing, and disseminating course content and material; (3) in supplementing lecture materials, facilitating student communication and interaction with faculty and pairs, and providing feedback to students” (p.7). Furthermore, a LMS offered “efficiency, convenience, and class organization and management” (Abdous, p. 7, 2013).

Student and material interaction. For students to be successful in ODL apprenticeship trades training, they had to stay engaged with the material (ITA & VCC, 2007). Educational technology such as the use of LMS ensured the students’ access to the material, but access did not equal engagement (Abdous, 2013).

According to Herrington and Oliver (2000), the ODL environment provided a number of communication tools, assistance, coaching, and feedback that facilitated students’ engagement with course material. Thus, the design of learning activities provided opportunities for students to interact with course content such as an online simulation of a plumbing lesson with schematic designs. Choosing a relevant collaborative activity to engage students was more likely to allow students to internalize, understand, and remember material (Bonwell & Sutherland, 1996). Furthermore, “apprentices learn dexterity skills required for their trade faster when using simulation technology” (CAF-FCA, 2013, p. 14). Although simple online tasks worked well to support low-level learning, the design of the learning environment needed to include more complex tasks particularly those requiring some form of human interaction which, for online learning environments, meant social and physical aspects of the learning environment (Bonwell & Sutherland, 1996; ITA & VCC, 2007; Kaptelinin & Nardi, 2006).

Animations and simulations. A recent study reported that hands-on and practical training activities were the most important parts of apprenticeship trades training and included demonstrating the operation of equipment or the building of an object (ITA & VCC, 2007). Animations and simulations could provide a foundation for "presenting a formalized, simplified and manipulable model of the system that can be changed based on learners' skills and need" (Stoilescu, 2013, p. 95). Furthermore, Stoilescu argued that "the pace of practice can be changed to suit learners' needs" (p. 95). Animations and simulations could provide "scaffolding of parameters used in real practices" — for example, describing the basic operation of equipment in a step-by-step process could provide the foundation for further learning. Simulations might provide advanced learning opportunities for students by enabling them to "interact with animated software replicating an operation of equipment, and to receive feedback on their input in real time" (ITA & VCC, 2007, p. 43). According to CAF-FCA (2013), the use of animations rather than actual equipment to show an operating system minimized safety concerns (p. 16). Furthermore, CAF-FCA (2013) noted that using animations and simulation lowered the cost of training because the software detected and corrected "student errors more efficiently than an instructor [could]" (p. 16) and it consumed less energy, fuel, and materials than actual equipment would.

Simulations offered a "level of complexity . . . so that tasks become progressively more challenging" (CAF-FCA, 2013, p. 17). They could also be supported in other technologies, such as virtual reality (VR). A study by Kopp and Burkle (2010) on the affordances and constraints in medical practice training programs using virtual patients provided insight regarding potential opportunities for other industries to implement VR tools in training programs, such as identifying affordances of constructing objects. In the study Kopp and Burkle (2010) compared "implications across virtual patients, standardized patients and human patient simulations" and determined that "virtual patients could be used to train many aspects of medical competencies" (p. 3).

Remote, hands-on training. The combination of face-to-face and technology-based teaching provided an effective hybrid learning environment for apprenticeship trades training. While much of the theory could be provided by online instruction, it is "important to stress that apprenticeship training deliverers that use . . . [educational technologies] do not . . . [fully] substitute for actual experience using real machinery and equipment in a work setting" (CAF-FCA, 2013, p. 17). Therefore, while some of the technical requirements could be delivered online, the face-to-face component allowed for supervised, real-life, hands-on construction of objects (ITA & VCC, 2007). This component did not need to be completed in a traditional classroom environment (ITA & VCC, 2007) as long as apprentices had access to lab environments where they had hands-on experiences with real-life experiments. Remote training could be implemented at employers' work sites through collaboration and partnership with the training institution (ITA & VCC, 2007). The employer could teach the apprentice by following the institutions' learning objectives, training tasks, and instructions about assessing students' hands-on skills (ITA & VCC, 2007).

The role of the instructor. In Canada, instructors in traditional face-to-face apprenticeship trades programs "play four important roles: (1) they manage the pace of learning, (2) they explain the subject matter, (3) they identify and address learning problems, and (4) they motivate apprentices to succeed" (CAF-FCA, 2013, p. 24). Furthermore, traditional face-to-face instructors have launched a variety of pilot ODL apprenticeship trades training programs (Hartwig, 2007) without much resistance by the institution.

Institutions which do not recognize instructor roles and involve them with design and development of ODL activities such as simulation may encounter resistance. According to CAF-FCA (2013), “one factor that may account for resistance to the use of simulation technology is its introduction as a *fait accompli* without any input from instructors” (p. 17). Instructor roles to be included in ODL design and development need to be constructed so as to “recognize learning challenges and address them so this format may still be the best for those apprentices who struggle with their Essential Skills” (p. 22). Examples of such programs included Camosun College’s second-year culinary arts apprenticeship training program and Vancouver Community College’s automotive collision apprenticeship training program (ITA & VCC, 2007). These types of ODL programs typically required institutional support as they required additional funding and instructor support for using technologies in their programs (Berge, 1998; Hartwig, 2007; Rockwell, Scheuer, Fritz, & Marx, 1999). Research has shown that a lack of institutional support decreases instructors’ incentives to initiate or sustain online education for apprenticeship trades (Hartwig, 2007; Wilson, 2001). According to CAF-FCA (2013), in the absence of external financial support to cover development costs “many colleges and training centres will find only a weak business case for extending the online model to apprenticeship training” (p. 4).

In addition to lacking administrative support many ODL instructors (including apprenticeship trades instructors) were slow in accepting ODL because they were not fully prepared to deliver content online and they required technical support and training in instructional methods (Hartwig, 2007; ITA & VCC, 2007; Wilson, 2001). Institutions like Nova Scotia Community College provided their online apprenticeship trades instructors with in-house training in online instruction (Hartwig, 2007; NSCC, 2011b). This type of institutional support for instructors played a significant role in the successful delivery of online programs.

Activity Types

According to Brophy and Alleman (1991), activities are "anything students are expected to do, beyond getting input through reading or listening, in order to learn, practice, apply, evaluate, or in any other way respond to curricular content" (p. 9). ODL activities should be designed so as to be authentic (Reeves, Herrington, & Oliver, 2002). To accomplish this, Reeves et al. suggested that the activities should have 10 characteristics. They must

- have real-world relevance;
- require students to define the tasks and sub-tasks needed to complete the activity;
- comprise complex tasks to be investigated by students over a sustained period of time;
- provide the opportunity for students to examine the tasks from different perspectives, using a variety of resources;
- provide the opportunity to collaborate;
- provide the opportunity to reflect and involve students' beliefs and values;
- be integrated and applied across different subject areas and lead beyond domain-specific outcomes;
- be seamlessly integrated with assessment;
- create polished products valuable in their own right rather than as preparation for something else; and
- allow for completing solutions and diversity of outcome (p. 565).

In the current study, activities included use of educational technologies such as the LMS, simulations, animations, and video conferencing. These activities using simulations, animations, and video conferencing had to be effectively integrated with the LMS. Furthermore, apprenticeship training involved solving real-world problems; therefore, the online distance activities needed to be relevant to the apprenticeship trade.

Affordances of Online Technologies

Gibson (1977) defined the term *affordances* as “properties of the environment relative to an animal” (organism) that allowed the organism to carry out a given function (p. 9). Norman (1988) extended Gibson’s (1977) definition to mean an object associated with perceived affordances. Affordances of ODL technologies in apprenticeship trades were the actionable (or perceived) properties and relationships between individuals and objects—in this case, online technologies (Gibson, 1977; Norman, 1988).

Affordances also referred to what individuals could do with objects. They could be restricted to internal or external influences such as physical characteristics, individual behaviors while solving problems, and specific beliefs that might influence the creation of, or constrain the use of, online technologies (Kaptelinin & Nardi, 2006). Training activities in apprenticeship trades programs should ideally focus on solving relevant, real-world problems (Sawyer, 2006).

Applied learning outcomes included constructing an object or drawing a plan on paper or electronically. Training activities designed and developed for online apprenticeship trades programs varied for each trade and because they mirrored important real-world situations, they involved specific implementation challenges when it came to meeting practical hands-on requirements effectively. Online technologies provided affordances to the extent that students gained the time to think through and respond to sequential, reality-based stimuli (problems, for example) with the ability to repeat, review, or explore the myriad conditions of a given situation in a cost-effective and physically safe environment.

The literature identified declining accessibility and the high training costs of traditional face-to-face apprenticeship trades training programs as major problems facing Canadian workforce development (Hartwig, 2006; Norman & Langhill, 2006). Accessibility and cost concerns were compounded by the amount of time a student was away from work while attending face-to-face, on-campus training. However, apprenticeship trades instructors' reluctance or inability to apply best practices to the design and development of such online programs may also have been a significant underlying reason for the perceived slow growth of ODL in apprenticeship trades training (Norman & Langhill, 2006; ITA & VCC, 2007).

The literature did not fully reveal the design and development implications of the affordances of online distance learning technologies to enable or constrain instructors who were teaching in apprenticeship trade ODL programs. The gap in the research that was identified in this study was a lack of information about instructors' experience with the design, development, and delivery of ODL apprenticeship programs and educational outcomes. Furthermore, there was insufficient data on how the backgrounds of students in ODL apprenticeship programs influenced the way apprentices used digital technologies.

Activity Theory

Activity Theory (AT) offers a framework that allows for the development of a broader perspective on online electrical apprenticeship training programs. The literature provided some precedents for such an approach. Issroff and Scanlon (2002) applied activity theory to technology and viewed online learning as an activity that necessarily included human-computer interaction and thus was influenced by other activities within online systems (e.g., rules and regulations governing an activity) and by the instructor's ability to design and develop ODL courses. According to Jonassen and Rohrer-Murphy (1999), the design and content of apprenticeship trades programs needed to comply with the "rules [that] mediate the relationship between the subjects and the community . . . in which they participate" (p. 75). Rules, including industry accreditation, competencies, and organizational policies, governed all activities in apprenticeship trades education as well as the techniques that instructors used to teach relevant content. These rules had the potential to encourage or hinder adoption of ODL technologies in the development of apprenticeship trades training programs and they also shaped the research design. In this section, the history of AT was described and it was argued that this framework was useful for analyzing the design, development, and delivery of ODL electrical apprenticeship trade programs.

History of Activity Theory

According to Engeström (2001), there have been three generations of AT. The first generation was attributed to a Soviet theorist named Rubinshtein (Bedny & Karwowski, 2010; Nardi, 1998; Wilson, 2009) who also had historical links with Vygotsky (1978). Vygotsky (1978) described human activity as being mediated by tools, which were necessary to the development of individual thinking. His theory was expanded in the works of Rubinshtein (1957) who described how humans interacted with an object in an activity (Bedny & Harris, 2005). Wilson (2009) argued that Rubinshtein originally introduced the "philosophical category of 'activity' into psychological soil" (p. 120). Bedny and Harris (2005) suggested that applying the theory of cognition provided useful "ways of thinking about activity, offering a nontraditional viewpoint on the understanding of human work" (p. 130). Figure 2-1 depicted the basic elements of the first generation of AT, which described a system as consisting of a subject (a human) who interacted with an object to obtain an outcome by using certain tools.

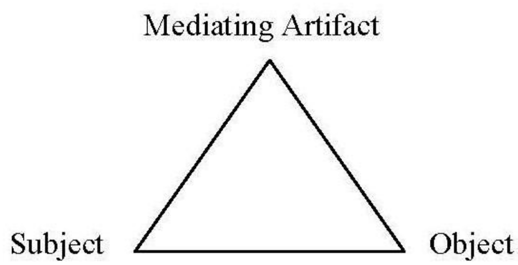

Figure 2-1. First-generation activity theory depicting the basic interaction of subject and object by way of tools (mediating artifacts). Adapted from Engeström (1999). Permission for use granted by the author on May 19, 2013.

The second generation of AT was further developed by Leont'ev (1978) who expanded Vygotsky's (1978) perspective to include three levels of activities. Leont'ev explained that the three levels work collectively and concurrently with motives (the motivation), goal (the action), and condition (outcome).

The third generation of AT included additional elements of community, rules, and division of labor (Engeström, 1987). This expanded version of AT is known as the activity system (Fretwell, 2003; Issroff & Scanlon, 2002; Mwanza & Engeström, 2003). Mwanza and Engeström (2003) continued to build on Leont'ev's activity system, resulting in the activity systems triangle model (Figure 2-2) which focused on a mediation-type relationship with the other elements of an activity system.

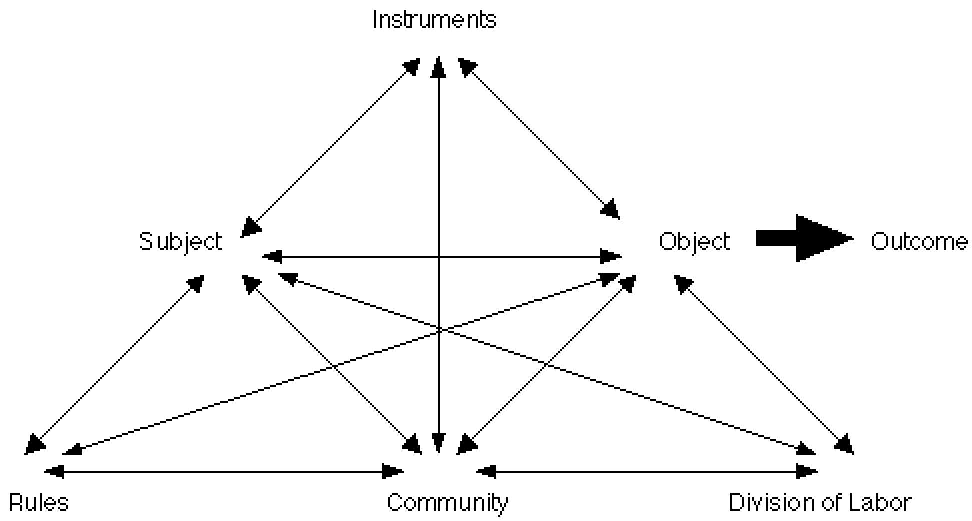

Figure 2-2. Activity system modified triangle model showing the relationships among the elements. Adapted from Mwanza *&* Engeström (2003). Permission for use granted by the author on May 19, 2013.

In this activity system model, artifacts were important and inseparable components of human performance (Kaptelinin & Nardi, 2006). Engeström (2001) explained that a model that allowed for “dialogue, multiple perspectives, and networks of interacting activity systems” (p. 135) helped clarify the contradictions in and outcomes of the systems.

Analysts have used elements of the activity systems model as a theoretical framework to understand students’ learning experiences within an educational setting (Issroff & Scanlon, 2002). Key considerations included human intentionality, the asymmetry of people and things, the importance of human development, and the idea that culture and society shape human activity. Each element then interacted with all other elements (Jonassen, 1991; Jonassen & Rohrer-Murphy, 1999; Kaptelinin & Nardi, 2006; Nardi, 1996; Robertson, 2007). It was found that elements within such systems could not generate outcomes individually (Jonassen, 1991; Jonassen & Rohrer-Murphy, 1999; Kaptelinin & Nardi, 2006; Nardi, 1996).

Figure 2-3 showed how the activity system model could be applied to the electrical ODL apprenticeship program. An activity system for ODL program development consisted of online instructors (subjects) engaging in using the fire alarm activity (object). The tools mediating this activity were technologies such as the LMS. The community component involved the apprenticeship. Rules included government policies or institutional guidelines. The division of labor corresponded to the roles adopted by the ODL instructor and the distribution of teaching tasks.

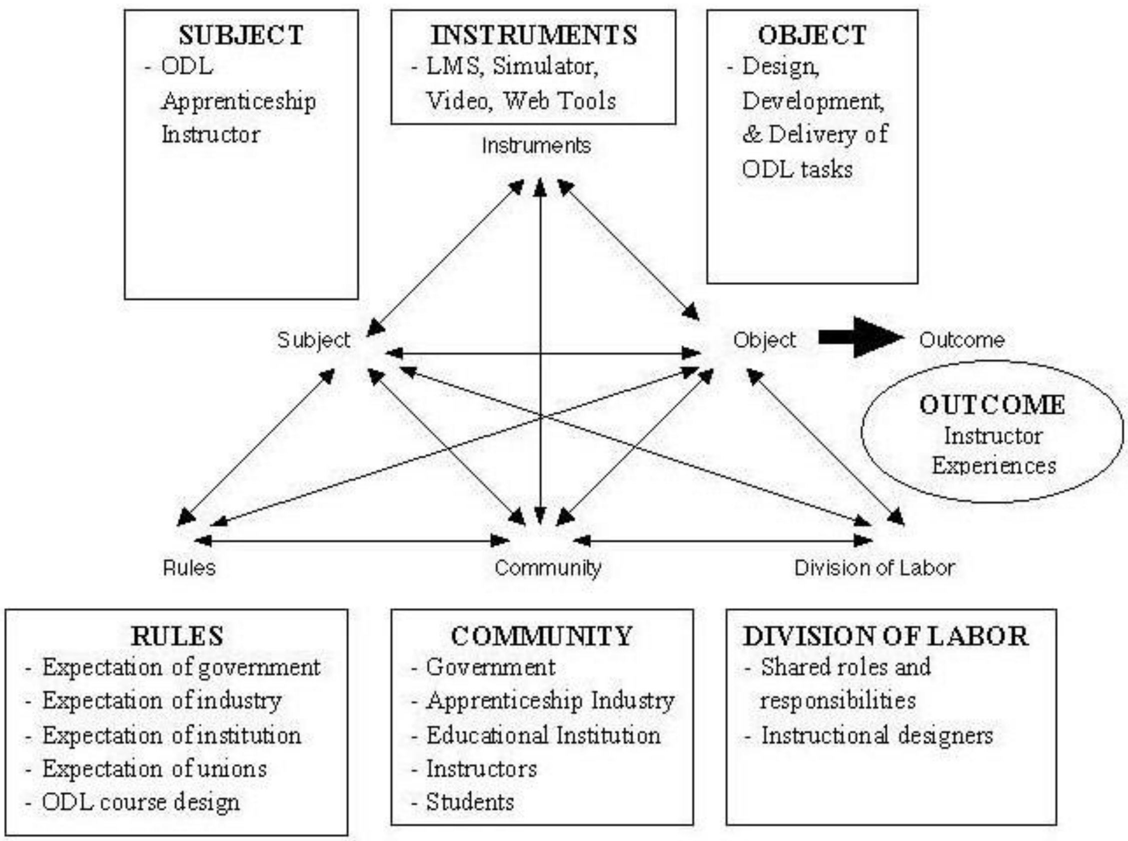

Figure 2-3. Activity system modified triangle model showing the relationships among the elements and ODL electrical apprenticeship. Adapted from Mwanza & Engeström (2003). Permission for use of Activity Systems figure granted by the authors on May 19, 2013.

The object of an activity would be a practical task: the task could be physical such as constructing a house, soft such as using computer program simulations, or conceptual such as grasping and applying a theory (Jonassen & Rohrer-Murphy, 1999). The transformation from object to outcome was “the motive of the activity” (Jonassen & Rohrer-Murphy, 1999, p. 65). The motive was ultimately defined by goals that provided a rationale and context for the activity (Kaptelinin & Nardi, 2006; Kopp, 2009). Therefore, soft activities such as simulations used within online apprenticeship training programs helped identify any barriers associated with ODL design, development, and delivery of apprenticeship trades training. An example of such soft activities was a simulation of how a fire alarm safety system operates.

An activity system was based on five principles which represented a broad conceptual system, rather than on a highly predictive theory (Kaptelinin & Nardi, 2006). All five principles were part of an integrated system and were connected with various aspects of the activity. First, a “collective, artifact-mediated and object-oriented activity system, seen in its network relations to other activity systems, [was] taken as the prime unit of analysis” (Engeström, 2001, p. 136). This principle allowed an understanding of the “background of entire activity systems” (p. 136). In the current study, the ODL electrical apprenticeship program served as the prime unit of analysis.

The second principle stated that an activity system involved “a community of multiple points of view, traditions and interests,” created by “the division of labor in an activity” (Engeström, 2001, p.136). For example, in an ODL electrical apprenticeship program, the community was comprised of students, instructors, and other individuals in the network, and their perspectives comprised the multiple points of view on the activity.

The third principle stated that an activity system changed its configuration with time (Engeström, 2001). Analysis of a system required gaining knowledge of the local history of the activity and its objects as well as the history of the theoretical ideas and tools that shaped the activity. For example, in an ODL electrical apprenticeship program, the types of competencies, such as those for electrical motor diagnostics tools changed. The diagnostic tools were adapted as activities within simulators for an online learning environment.

The fourth principle pointed to the centralized "role of contradictions as sources of change and development" (Engeström, 2001, p. 137). An example of a contradiction of an activity in a system was when an activity element adopted a new activity system element such as a technology (LMS) and this new element led to an "aggravated secondary contradiction" (p. 137) caused by rules (government) or division of labor (instructional designers).

Engeström (2001) further explained that contradiction reflected the "structural tensions within and between activity systems" (p. 137). The AT framework also revealed the tension and contradictions between subjects (instructors) and objects (learning tasks) (Engeström, 1999; Nardi, 1996). According to Engeström (1999) the basic contradiction in an activity system was the result of tension or conflict between individual actions and individual goals, such as the contradiction in an instructor's teaching practice that occured when a new online technology clashed with other activity system elements. In the current study, contradictions occurred when an ODL apprenticeship trades instructor wanted students to learn how to use a tool, but the ODL technology had limitations such as Internet speed and access that interfered with the instructor's ability to convey the intended message. Identifying specific sources of tension and contradiction provided a basis for determining to what extent instructors faced barriers when designing and delivering online apprenticeship trades programs.

The fifth principle was that the "expansive transformation is accomplished when the object and motive of the activity [what a learner can do]" coincided (Engeström, 2001, p. 137).

The expansive transformation was reflected in the difference between what learners did on their own without instruction and what they learned to do only through instruction— the ZPD (Kaptelinin & Nardi, 2006; Vygotsky, 1978). In a study by Kaptelinin and Nardi (2006), the authors argued that online learning environments lent themselves to self-directed achievement. Students' levels of individual development, for example, were determined by comparing what students achieved on their own with what they achieved through instruction (Kaptelinin & Nardi, 2006). Accordingly, tasks given to the apprenticing learner had to be within the reach of the learner's current ability level; throughout the apprentice learning process, larger and more complex skills needed to be broken down into smaller ones (Vygotsky, 1978).

Vygotsky (1978) suggested that strategies such as scaffolding be used to enhance learning within the ZPD by structuring an activity differently so that the learner could perform the activity at a higher level by building on the knowledge of others. For example, in the current study, an electrical trades apprentice learned to change an electrical receptacle by consulting more knowledgeable individuals (such as the instructor). Through a series of social interactions, the apprentice gained insight into methods to achieve the goal of changing an electrical receptacle.

Theoretical Framework

The third-generation activity systems model was the theoretical framework used in the study to investigate how the affordances of ODL technologies enabled or constrained instructors who designed, developed, and taught in apprenticeship trade programs. AT was used to analyze the interactions among people, culture, history, and life experiences and to explore how they influenced the way people communicated through digital technologies. It also provided a clear, effective framework to examine consciousness (the human mind) and activity (human interaction with objects), which involved people interacting with technology to design ODL environments (Jonassen & Rohrer-Murphy, 1999; Kaptelinin & Nardi, 2006).

In addition to the theoretical ideas and tools that have shaped the activity, the theories of constructivism and constructionism were used to explain the shift from the traditional behavioral approach to apprenticeship trades training. Constructivism is a philosophy of education and a cognitive learning theory that assumes that individuals make meaning based on interactions between their experiences, social interactions, and ideas (Crotty, 2004; Jonassen & Rohrer-Murphy, 1999). AT's emphasis on the construction of knowledge reveals its constructivist roots (i.e. the minds of the apprentice learners) (Seely Brown et al., 1989).

Constructionism is a philosophy of education and a learning theory developed by Seymour Papert (1980). It described knowledge as constructed (not created) through interactions with the environment and developed within a social context (Crotty, 2004; Hay & Barab, 2001; Jonassen & Rohrer-Murphy, 1999). According to Ford and Lott (n.d.), "the pedagogy of constructivist learning theories such as activity theory, social constructivism and situated learning was altered and empowered through the use of technology as a tool in learning" (p. 2). Therefore, the activities delivered through constructivist methods such as in the ODL apprenticeship environment supported the natural complexity of content, engaged students in knowledge construction, and presented instruction through real-world activities (Hay & Barab, 2001).

Since the environment profoundly influenced the relationship between subjects and objects (Mwanza & Engeström, 2003), an activity system was used in the current study to explain ODL apprenticeship trades instructors' reluctance or inability to apply best practices to the design and development of apprenticeship trades online training programs. The elements of the activity system set the context of what was studied. Mwanza and Engeström's *(*2003*)* activity system model illustrated interactions between people and technology, thereby allowing a greater understanding of their relationships (Jonassen & Rohrer-Murphy, 1999; Kaptelinin & Nardi, 2006). In the case of ODL apprenticeship trades training, the elements of the system included ODL instructors, the apprenticeship community, instructional designers, governments, computer software, and the practical tasks.

The current study also used Mwanza and Engeström's *(*2003*)* eight-step activity system model abstraction tool to guide the development of interview questions regarding the activity being investigated. The interview questions were designed to elicit instructors' perspectives on their design, development, and teaching experiences and the transition from traditional face-to-face learning environments to ODL learning environments (Table 2-1).

Table 2-1

Mwanza's and Engeström's Eight-step Activity System Model (Modified)

Steps	**Elements**	**Questions to ask in ODL Apprenticeship Trades Programs**
1	Define an Activity	*What sort of activity or interest?* e.g., *ODL electrical apprenticeship program.*
2	Objective	*Why is the ODL electrical apprenticeship program taking place?*
3	Subject	*Who is involved carrying out the ODL electrical apprenticeship program?*
4	Tools	*By what means are the instructors performing the ODL electrical apprenticeship program? What are the technologies and materials used?*
5	Rules and Regulations	*Are there any cultural norms, rules, or regulations governing ODL electrical apprenticeship activity?*
6	Division of Labor	*Who is responsible for what when carrying out the design and development of ODL electrical apprenticeship programs?*
7	Community	*What is the environment in which the ODL electrical apprenticeship program is carried out?*
8	Outcome	*What is the desired outcome in the ODL electrical apprenticeship program?*

To understand further the impact of online technologies in ODL environments, it was necessary to analyze the design of activities that relied on educational technologies and then to evaluate the efficacy of those activities (Fretwell, 2003; Issroff & Scanlon, 2002; Mwanza & Engeström, 2003). Such analysis was especially important for apprenticeship trades programs, which relied on hands-on activities—not passive learning—to train students for jobs. Kaptelinin and Nardi (2006) suggested that guiding principles be used as a research checklist framework that could "(1) provide a preliminary over-view of potentially relevant contextual factors, (2) select appropriate tools for further exploration, and (3) evaluate the limitations of those tools" (p. 270). Engeström's (2001) principles were used in this study for this purpose.

Furthermore, Kaptelinin and Nardi's (2006) five principles of AT were used to analyze the activity system's eight elements and to guide further investigation of the design, development, and delivery of the activity. These principles included (a) the hierarchical structure of the activity; (b) social and physical aspects of the environment; (c) learning, cognition, and articulation; (d) development; and (e) the zone of proximal development (ZPD). Table 2-2 is a depiction of how the AT elements and principles are connected.

Table 2-2

Activity Theory Framework Principles

(Adapted from Kaptelinin and Nardi (2006) and Engeström (2001))

Framework Principles	Activity Theory Elements	Inquiry	Tasks
Principle 1: **Means/Ends** (Hierarchical structure of activities)	1. Activity 2. Object 3. Subject 4. Instrument 5. Rules 6. Division of Labor 7. Community 8. Outcome	- Functions of online technology - Limitations of online technology - Conflicts of learning objectives with online technologies - Community influences in design and development ODL apprenticeship programs	Describe the prime unit of analysis (the "collective, artifact-mediated and object-oriented activity system, seen in its network relations to other activity systems") (Engeström, 2001, p. 136). Identify the goals of the apprenticeship trades community (Kaptelinin & Nardi, 2006).
Principle 2: **Environment** (Social and physical aspects of the environment)	1. Object 2. Subject 3. Instrument 4. Rules 5. Division of Labor 6. Community 7. Outcome	- Concept and vocabulary of ODL - Online activities designed for ODL apprenticeship programs - Importance of online for apprenticeship programs - Availability of online technology - Online technology integration - ODL consistency with other apprenticeship programs - Online work environment - Activities distributed - Rules regulating online technologies - Available resources	Identify how activities and support technologies and are used in ODL environments, recognizing that people achieve their goals by transforming objects (Kaptelinin & Nardi, 2006). Identify the "community of multiple points of view, traditions and interests" (Engeström, 2001, p. 136).

Framework Principles	Activity Theory Elements	Inquiry	Tasks
Principle 3: **Learning, Cognition, and Articulation**	1. Object 2. Subject 3. Instrument 4. Rules 5. Division of Labor 6. Community 7. Outcome	- Time and effort learning to use the online technology - Avoidance of unnecessary learning using online technology - ODL material access - ODL student self-evaluations - Apprenticeship problem-solving representation - Pilot test of ODL apprenticeship program - Types of ODL activities	Develop an understanding of the activity's internal (mental) and external components (Kaptelinin & Nardi, 2006). Identify the learning "role of contradictions as sources of change and development" (Engeström, 2001, p. 137)
Principle 4: **Development** (History)	1. Object 2. Subject 3. Instrument 4. Rules 5. Division of Labor 6. Community 7. Outcome	- Implementation of online technology - Instructor experience with online technology - ODL instructor attitude toward use of technology - Apprenticeship community attitude toward online technologies - Negative or side effects of use of online technologies	Analyze the history of target activities to reveal the main factors influencing the development of online apprenticeship trades training programs (Kaptelinin & Nardi, 2006). Develop an understanding of how the activity system "take[s] shape and get[s] transformed over lengthy periods of time" (Engeström, 2001, p. 136).
Principle 5: **Zone of Proximal Development** (Scaffolding)	1. Object 2. Subject 3. Instrument 4. Rules 5. Division of Labor 6. Community	- ODL learner assessment using online technologies - Scaffolding strategies used to enhance ODL learning	Understand the learning transformation when the object and motive of the activity are successfully completed (Engeström, 2001).

Framework Principles	Activity Theory Elements	Inquiry	Tasks
	7. Outcome		Develop an understanding of the instructor's use of scaffolding for enhancing student learning within the ZPD.

In the study, specific online technologies were identified that required students to apply their ODL apprenticeship training to realistic problems. As the researcher I explored how instructors interacted with technologies in the online environments and applied AT to understand the relationships which involved people interacting with technology within the designated activity. Nardi (1996) noted that the tools in AT are both "created by people and used to mediate activity" (p. 38). Consequently, it was not startling that AT proved useful in understanding the design, development and delivery of ODL electrical apprenticeship programs. The way Table 2-2 was laid out represented the research design. The research was guided by five principles using eight elements of an Activity System; therefore the interview questions were divided by the eight elements and the interpretation of the data was separated by each principle.

Summary

The literature review explored the theoretical foundation of and research on the use of online learning technologies by instructors in distance learning environments within the context of apprenticeship trades education programs. The major theoretical framework for the study included using activity theory to investigate the affordances of ODL technologies to enable or constrain instructors who designed, developed, and taught in apprenticeship trade programs. The elements of the activity systems model could be used to understand students' learning experiences within an educational setting. Five guiding principles were utilized to analyze the activity system and guide further investigation of the activity: (a) the hierarchical structure of the activity; (b) social and physical aspects of the environment; (c) learning, cognition, and articulation; (d) development; and (e) the ZPD. In Chapter Three, the characteristics of qualitative research using a case study approach were described, along with the reasoning for choosing a multiple case study design.

Chapter Three: Research Design

In Chapter Three the methodology of the study, which was qualitative in nature, was described. The characteristics of qualitative research as well as the basis for choosing this particular methodology were presented. The research questions were reviewed and the case study approach was discussed along with the reasoning for choosing a multiple case study design. The population, sample, and instruments were described, followed by an explanation of how the data were collected and analyzed. Finally, this chapter concluded with a discussion of relevant reliability and validity issues, ethical considerations, and limitations of this study.

Research Questions

The focus of this research was on discovering the affordances and constraints of online learning technologies used by instructors in distance learning environments within the context of electrical apprenticeship trades education programs. The following research questions guided the current inquiry: How did the affordances of ODL technologies enable or constrain instructors who were teaching in an apprenticeship trade ODL program?

The following sub-questions were used to investigate the topic further:

1. How might the affordances and constraints affect the design and development of online distance apprenticeship trades training programs?
2. In what kinds of social and physical environments did online technologies integrate with environmental requirements, tools, resources, and social and cultural rules?
3. How might online distance apprenticeship trades programs affect training competencies and could these competencies be addressed in specific training activities?
4. How might implementation of online distance apprenticeship trades programs

influence the design of future apprenticeship trades programs?

5. How might the development of online distance apprenticeship trades programs affect instructors' abilities to measure student assessment and achievement levels?

Methodology

This study involved an interpretive paradigm that viewed inquiry as a process that recognized opposing views, conflicts, and, in some cases, contradictions (Crotty, 2004). According to Burrell and Morgan (1979), the interpretive paradigm position often called for qualitative research methods because it "is informed by a concern to understand the world as it is, to understand the fundamental nature of the social world at the level of subjective experience" (p.28). Furthermore, a qualitative research method was applied in this study because it allowed for accurate and thoughtful ways to answer predefined research questions (Bogdan & Biklen, 2002).

Qualitative research design.

A qualitative research design was used to conduct this study. Denzin and Lincoln (2003) suggested that a qualitative study should have a design that "situates researchers in the empirical world and connects them to specific sites, persons, groups, institutions, and bodies of relevant interpretative material, including documents and archives" (p. 36). Qualitative research focused on the close relationship between the researcher and what is researched (Denzin & Lincoln, 2003). Determining which research design worked best for the participants was important in achieving insight into the phenomenon in question. Furthermore, qualitative research consisted of a set of interpretive, material practices that made the world visible using field notes, interviews, conversations, recordings, and journal notes (Denzin & Lincoln, 2003).

Creswell (2007) discussed the characteristics of qualitative research which included the natural setting, researcher as an instrument, multiple sources of data, data analysis, participants' meanings, emergent design, theoretical lens, interpretive inquiry, and holistic account. Each of these characteristics was presented in the current study as described in this section.

This study was conducted in the natural setting of the participants, such as their offices or a quiet coffee shop. The participants described their experiences and the researcher interpreted what was said, heard, or understood, thus making the researcher an instrument in the research. The interview was focused on learning about the online distance learning (ODL) apprenticeship instructor experience for designing, developing, and teaching online apprenticeship electrical trade programs. Multiple sources provided data for analysis and development of themes.

Case study research.

A case study research approach was used to gather data and responses to in-depth, semi-structured, open-ended interview questions. Case study research gave meaning and personalized findings for specific institutions and instructors. Furthermore, in this study the multiple case study design was utilized and included three cases and six individual instructors distributed among the three electrical online apprenticeship programs. Six individual instructors' were examined for design and development experiences in order to identify the affordances and constraints of ODL technologies in electrical apprenticeship trades training programs. Since there were three cases, a multiple case study design approach was used to contribute to the rigor of the study (Yin, 2003) and to enhance the external validity of the findings (Merriam, 2009).

Creswell (2009) suggested that case-studies are "an exploration of a bounded system" (p. 61) and Stake (1995) stated that "as a form of research, case study is defined by interest in an individual case, not by methods of inquiry used" (p. 44). Merriam (2009) suggested that case-study was a methodology which included investigating whether past unknown relationships and variables could be anticipated to emerge from case studies. This study explored the past relationships from traditional face-to-face electrical apprenticeship programs to online distance electrical apprenticeship programs.

For the purpose of this study, Yin's (2009) case study definition as a qualitative approach that allowed the researcher to investigate contemporary phenomena was utilized. Yin (2009) further described case study research as an empirical method of inquiry that explored contemporary phenomena within a real-life situation, particularly when the boundaries among phenomena and context were not apparent. In this case study, ODL electrical apprenticeship instructors described their real-life experiences of designing, developing, and teaching electrical apprenticeship programs in an online distance learning environment.

Yin (2003) described case study research as "a research strategy which comprises an all-encompassing method—covering the logic of design, data collection techniques, and specific approaches to data analysis" (p. 14). All these strategies were applied in this study. The case study approach provided a clear data collection method and allowed for the use of detailed approaches to data analysis (Yin, 2009). Data was collected through interviews of ODL electrical apprenticeship instructors, document analysis, and online program shell review.

A case study research approach served to secure information about the ODL technology used in the electrical apprenticeship online distance program, an area of study in which little research has been conducted. Merriam (2009) noted that case studies were useful in presenting information in such areas of inquiry. The intent of this study was to gain a nascent understanding of the experience of ODL through a detailed description of what was involved in designing, developing, and teaching ODL electrical apprenticeship programs.

Creswell (2009) and Stake (1995) described four features of case study research: (a) identifying the case; (b) discussing the time and location parameters of the case; (c) ensuring that extensive detail was provided about the setting; and (d) completing a thorough portrait of the case. The four features identified by Creswell were addressed in the following sections as they related to this particular study.

Identifying the case. Cases must first be identified. In the current study, the cases were the electrical apprenticeship instructors who designed, developed, and taught at an institution; within each case there was potential for more than one instructor to participate. Fifty-five instructors from five institutions were pre-selected from the preliminary review of Canadian trade schools with ODL or hybrid, blended learning electrical apprenticeship programs.

Creswell (2009) suggested that, to avoid loss of depth in case studies, no more than five cases should be used. Therefore, five separate groups of electrical ODL apprenticeship trades instructors who have designed, developed, and delivered courses through an ODL format were invited to participate. Each group was bounded by the institution in which they worked. All included programs were recognized by their respective provincial apprenticeship trades accreditation authority (i.e., Red Seal Certification). Other criteria for institution selection included: being located in Canada, being provincially accredited, being publicly funded, and offering electrical ODL apprenticeship trades programs. Of the five invited institutions, only three participated. The identification of multiple institutions provided duplication in case selection (same trade requirements) and addressed the inclusion of multiple data collection activities in each case, which contributed to the overall trustworthiness and credibility of the study (Yin, 2009).

The 55 individuals invited to participate in the study were electrical apprenticeship instructors who developed, designed, and taught courses at the selected institutions. Criteria for instructors included that they must have participated in design and development of ODL, taught third- or fourth-year courses, delivered trades courses using an ODL format, and offered their courses in the current academic year. Random sampling was not possible for this research due to the small number of ODL electrical apprenticeship trades instructors. Six instructors agreed to participate.

Time and location parameters of the case. Selection of instructors started with an Internet search in February 2012 of the five institutions' websites (public domain) for potential candidates. If a contact name was not available on an institution's website, the department head's administrative assistant was contacted for names of instructors teaching online electrical apprenticeship courses. Each potential candidate was sent an email invitation to participate in an interview. The written invitation to participate explained that participants' responses would remain confidential, that participation was voluntary, and that participants could withdraw from the study at any time. A total of six participants from three institutions agreed to participate in the study. The interviews occurred between April and September 2012 at their institutions in two provinces. A list of the three cases from which six participants (instructors) were selected is in Table 3-1.

Table 3-1

A Total of Six Participants from Three Institutions

Case	**Institution Pseudonym (Cases)**	**Participant Pseudonym**	**3rd and 4th Year/Level of Instruction**
1	Institution One	Nike	Electrician Apprenticeship Program
2	Institution Two	Amp	Electrician Apprenticeship Program
2	Institution Two	Watt	Electrician Apprenticeship Program
3	Institution Three	Gorge	Electrician Apprenticeship Program
3	Institution Three	Current	Electrician Apprenticeship Program
3	Institution Three	Power	Electrician Apprenticeship Program

Identification of time, location, and setting parameters. Two of Creswell's (2007) features—identification of time and location parameters and provision of extensive details about the setting—were addressed in this section. Once instructors agreed to participate, each was contacted to obtain informed consent and to schedule a date, time, and neutral location for the initial interviews. After this initial contact, a confirmation email was sent to each participant. Neutral locations for conducting the initial interviews included a common room, instructors' offices, and a quiet corner in a coffee shop.

All of the initial individual interviews were completed in person during one session with the exception of one which was completed over two sessions. Although it varied slightly from participant to participant, the initial interview lasted approximately 90 to 180 minutes. Follow-up interviews were conducted with each participant approximately eight weeks after the initial interview.

All face-to-face interviews were audio recorded and participants were identified by pseudonym rather than real name. Audio recordings were sent to a professional transcriptionist who transcribed the interviews word-for-word. Overall, data collection took approximately eight months to complete.

Thorough portrait of the case. Completing a thorough portrait and meaning of the case was another important feature according to Creswell (2007) because it allowed the reader to understand the study through demographic information and data from in-depth interviews.

Multiple data sources were used to create a solid and thorough description of the phenomenon of ODL electrical apprenticeship instructor experiences in design, development, and instructional experiences (Merriam, 2009). Multiple sources of information were used because no single source of information could be trusted to provide a comprehensive perspective (Merriam, 2009). The multiple sources of data included the interviews of one ODL electrical apprenticeship instructor, document analysis, and online program shell review.

Multiple case study research.

Multiple case study design entailed the identification of the unit of analysis (Yin, 2003). In this study the ODL technology experienced by the six apprenticeship instructors in the three institutions was the unit of analysis.

The multiple case study approach allowed the researcher to explore in depth the ODL technologies employed in electrical apprenticeship trades training programs in a "bounded system" (Creswell, 2007, p. 73) and to collect detailed information using a variety of data collection procedures over a sustained period of time (Creswell, 2009; Stake, 1995). A bounded case was one that was separated out for research in terms of time, place, or small physical boundaries such as an activity, event, process, or group of people. The primarily focus of case studies was on an event or activity that involved individuals and their primary purpose was “describing the activities of the group” (Creswell, 2007, Stake, 1995).

One of the analytic benefits of having three cases was that the multiple cases allowed for direct replication (Yin, 2003). Thus, the analytic conclusions independently arising from the three cases were more powerful than those that would have come from a single case. Moreover, the contexts of the three cases were different. Yin (2003) argued that with this powerful benefit, “the external generalizability of the findings would be expanded immeasurably" (p. 53).

Using multiple case studies not only offered more convincing data than the single case method, but it also provided opportunities for factual duplication. For example, each case was equivalent to an experiment that either predicted a similar result or gave an anticipated alternative result (Yin, 2009).

Furthermore, multiple case studies allowed me to ask broad questions to understand the participant better and then to narrow the focus of the study as more data were collected. The concentrated focus on a specific participant allowed me to gather considerable documentation related to the case which provided an in-depth understanding about who the participants were as they related to other cases.

Pilot Testing

Prior to collecting data, the open-ended interview questions were piloted with two individuals, both of whom have doctoral degrees—one in educational technology and the other in educational leadership. The open-ended interview questions were the unit analysis and were constructed by following the Kaptelinin & Nardi (2006) Activity Theory and interaction design principles.

These participants provided feedback on the interview questions regarding wording, flow, and clarity. Based on the pilot interviews, only minor changes, such as revisions to increase clarity of the interview questions, were made. The piloting procedure also allowed the researcher to become more familiar with the interview questions prior to collecting data and to confirm that the length of the interview was approximately 60 to 90 minutes which helped participants to make informed decisions regarding whether to participate in the study.

Data Collection

The research included multiple sources of data collection (interviews, field notes, and documents), rather than relying on one single data source. These sources of data collection provided opportunities for triangulation (Denzin & Lincoln, 2003). Multiple sources as evidence were utilized to address historical, attitudinal, and behavioural concerns (Yin, 2003).

One of the data collection methods utilised was open-ended interviews with follow-up interviews. Based on Kaptelinin's and Nardi's (2006) Activity Theory and interaction design principles, interviews with participating instructors addressed five principles: (a) instructors' examples and explanations regarding the hierarchical structure of the course, (b) social and physical aspects of the online environment, (c) instructors' perspectives on and competencies in the training, (d) instructors' past experiences with course development, and (e) instructors' perspectives about measuring student achievement levels in an ODL electrical apprenticeship trades course. Data collection started in early April 2012 after receiving approval from each of the three sites' Research Ethics Boards. At the end of September 2012, the data were reviewed to make sense of the information collected and to sort out the information into emergent thematic categories (Creswell, 2007).

Yin (2009) suggested that protocols should be developed for collecting data in case studies to ensure reliable procedures for each case. This study followed a modified version of Scagnoli, Buki, and Johnson's (2009) steps for data collection (Table 3-2).

Table 3-2

Steps in Case Study Data Collection

Steps	**1**		**2**	**3**
Strategies	**A:** Questionnaire	**B:** Semi-structured interview	In-depth study of documents	Follow-up interview

Adapted from "The Influence of Online Teaching on Face-to-Face Teaching Practices," by A. Scagnoli, B. Buki, & C. Johnson, 2009, *Journal of Asynchronous Learning Networks*, *13*(2), pp. 115−128. Copyright 2009 by Publisher.

Step 1-A: Questionnaire and Closed-ended Questions

The first interview began with a reminder of informed consent and confidentiality (no real names were used in the study) and a review of the definition of the activity that was the focus of the study. This part of the interview consisted of having participants complete a basic demographics questionnaire regarding age, gender, educational background, highest degree/education obtained, and previous educational technology experience. Participants were also asked to provide the number of years of teaching experience in an ODL environment.

Step 1-B: Semi-structured Interview

To understand better the impact of online technologies in ODL environments in the context of the activity being studied, an activity system model was applied. The first part of the semi-structured interview began with eight open-ended questions (Appendix C) about activities, goals, instructor involvement in designing and developing the course, the technology and representative materials used in the course, electrical apprenticeship trades training cultural norms, governing regulations, and representative examples of the community or environment. Additionally, participants were asked to describe the desired outcome in the apprenticeship ODL electrical apprenticeship trades course.

The second part of the semi-structured interview followed the Kaptelinin & Nardi (2006) five principles of activity theory (Appendix E) and asked participants to talk about a specific event in which the online technologies enabled or constrained apprenticeship program goals. The specific event questions were designed to probe participants' experiences in-depth regarding topics such as the integration of online technologies with environment requirements, tools, resources, and rules. More specifically, the questions asked participants to describe the internal and external components of activities that facilitated problem solving and what students could achieve on their own compared to what they could achieve through instruction. During the interviews the researcher observed each instructor using the LMS and the online activities (i.e., fire alarm simulations).

Step 2: In-depth Study of Documents

Another form of data gathering was through the study of documents. Several forms of documentary evidence were collected and examined. The researcher accessed the learning management system (LMS) course shell and examined each interviewee's learning activities and personally purchased the students' individual learning modules from the institutions' bookstores.

Observation was also used as a data collection method in this research but was limited to exploring and investigating the participant instructors' online courses as presented in their respective LMS and, while the researcher was present, witnessing their social interactions with other instructors. According to Stake (1995) as observations were made and time passed, knowledge was constructed. Field notes were collected during the initial interview and then each instructor's online learning modules were examined. These field notes were taken during the interviews with the participants. Thus, in the current study "observation" meant "access and review." Online course structure, instructional learning modules, design, and layout of content (LMS shell) including online hyperlinks to activities and resources as well as assignment descriptions and weightings were reviewed. Online links were also examined through which instructors and students navigated and accessed these various activities from a structural/course design perspective, noting potential barriers to use and navigability for users. This secondary observation was akin to document analysis in that course elements within the LMS were observed and analyzed without observing any "live" activity or student-instructor interaction.

Step 3: Follow-up

The follow-up interview was shorter in duration and less structured than the initial interview. Follow-up interviews were conducted through email or over the telephone (60 to 90 minutes) in which case they were audio recorded and then transcribed word by word. They occurred roughly eight weeks after the initial interview. The follow-up interview covered concluding questions that emerged from analysis of the first interview. Participants were also asked if there was anything else they would like to add regarding working with the ODL environment. The transcriptions and email responses were coded.

The follow-up interview served several purposes. First, as the researcher I allowed participants to express any additional thoughts regarding the ODL environment. Second, participants were asked additional questions about their work cultures and working conditions. The participants were allowed to share any thoughts they might have had after the initial interview as well as to clarify any unclear content. Participants were then asked to describe any internal and external barriers to using online technology in the electrician apprenticeship trades program and how, if at all, participation in the study affected participants' experiences of designing and developing ODL in electrician apprenticeship trades courses. The follow-up interview was designed to take approximately 30 minutes for each participant to complete via email communication or telephone.

Data validation and storage.

The primary evidence collected from the interviews consisted of the written interview notes, although interviews were recorded with a digital recorder (with each instructor's permission). For validation purposes, a member-check technique was used, in which instructors were asked to review the transcripts within two weeks of their respective interviews to confirm accuracy. Document evidence included institutional policies, course syllabi, class assignments, course assignment assessments, and other class materials. All collected case study evidence was compiled into a database, which became part of the research evidence in an effort to enhance the study's reliability (Yin, 2009). The database containing all data was stored in a digital, password-protected environment.

Data Analysis

Activity theory was the framework used in this study for examining consciousness (the human mind) and activity (human interaction with objects) in the context of using online technologies (Kaptelinin & Nardi, 2006). Thus, the three cases and six participant interview data were examined using activity theory systems as a theoretical lens to observe and analyze how ODL technologies were perceived and used for apprenticeship trades training (Jonassen, 1991; Jonassen & Rohrer-Murphy, 1999; Kaptelinin & Nardi, 2006; Vygotsky, 1978). Because activity theory systems were characterised by inner contradictions, the data analysis consisted of examining the relationship between subject and object as mediated by the elements of the activity system including (a) tools, (b) the overall online learning environment, (c) division of labor (including class group dynamics and student/instructor roles), and (d) rules (Jonassen, 1991; Jonassen & Rohrer-Murphy, 1999; Kaptelinin & Nardi, 2006; Nardi, 1996). Five activity theory principles were used in this study to analyze the design and development of ODL apprenticeship trades programs (Table 3-3).

Table 3-3

Framework and Data Analysis—Activity Theory Principles

Principle	**Activity Theory Description**
Principle 1: Means/Ends (Hierarchical structure of activities)	**Definition:** The extent to which online technologies enable or constrain apprenticeship program goals and provoke or resolve conflicts between different levels (motive, goal, and condition) in the activity system (Kaptelinin & Nardi, 2006). Activity is driven by a motive; the middle level is driven by a goal; and the bottom level is driven by the conditions and tools. **Analysis:** Identified the goals of the apprenticeship trade community. These goals were a result of a motive or need (subconscious) and the social or personal meanings of the activities at hand (Kaptelinin & Nardi, 2006). **Research Sub-question:** How might the affordances and constraints affect the design and development of ODL apprenticeship trades programs? **Unit Analysis/Instruments:** Interviews, document analysis.
Principle 2: Environment (Social and physical aspects of the environment)	**Definition:** The integration of online technologies with environment requirements, tools, resources, and rules that will transform objects through the social and physical environment (Kaptelinin & Nardi, 2006). This principle identified the activity theory approach applied to the environment with which individuals were interacting. According to Kaptelinin and Nardi (2006), the cognitive approach for making sense of a problem was the individual mental process for making connections between learning and the real world. **Analysis:** This research described how activities and supporting technologies were used in ODL environments, recognizing that people achieved their goals by transforming objects (Kaptelinin & Nardi, 2006). **Research Sub-question:** In what kinds of social and physical environments do online technologies integrate with environmental requirements, tools, resources, and social and cultural rules? **Unit Analysis/Instruments:** Interviews, document analysis
Principle 3: Learning, Cognition, and Articulation	**Definition:** The mental and external components of activities that facilitate problem solving (Kaptelinin & Nardi, 2006). **Analysis:** Developed an understanding of activities' internal (mental) and external components (Kaptelinin & Nardi, 2006). **Research Sub-question:** How might the online distance apprenticeship trades program affect competencies and could those competencies be addressed in specific training activities? **Unit Analysis/Instruments:** Interviews, document analysis

Principle	Activity Theory Description
Principle 4: Development (History)	**Definition:** Knowing how a phenomenon developed leads to understanding it (Kaptelinin & Nardi, 2006). **Analysis:** This research analyzed the history of target activities to reveal the main factors influencing the development of online apprenticeship trade training programs (Kaptelinin & Nardi, 2006). **Research Sub-question:** How might the implementation of ODL apprenticeship trades programs influence the design of future programs? **Unit Analysis/Instruments:** Interviews, document analysis
Principle 5: Zone of Proximal Development (Scaffolding)	**Definition:** What students can achieve on their own compared to what they can achieve through instruction (Kaptelinin & Nardi, 2006). **Analysis:** Developed an understanding of the instructor's use of scaffolding for enhancing student learning within the zone of proximal development (ZPD). Scaffolding entailed structuring an activity differently so the learner could perform the activity at a higher level using the knowledge of others (Vygotsky, 1978). **Research Sub-question:** How might the development of online distance apprenticeship trades programs affect the instructor's ability to measure students' achievement? **Unit Analysis/Instruments:** Interviews, document analysis.

Data analysis procedures.

A qualitative thematic strategy of data analysis was used to organize the data in a systematic manner. This systematic organization allowed important themes to emerge from the data across the three institutions (Miles & Huberman, 1994). The data were categorized and synthesised, coded, examined for themes, and triangulated.

The first step was to categorize and synthesize the study data so that the meanings and essence of the phenomenon could emerge. To identify statements in the interview transcriptions and field notes relating to individual instructors' experiences, a process of horizontalization was applied. Horizontalization is "the process of laying out all the data for examination and treating the data as having equal weight" (Merriam, 2009, p. 26). Applying horizontalization, significant statements and phrases were listed in a spreadsheet from the verbatim transcriptions of each instructor concerning the online technology. Each statement was treated as having equal worth and then a list of nonrepetitive, nonoverlapping statements was constructed.

Once statements were identified thematic analysis was employed to confirm or reject the validity of the assertions from various data sources. Data were interpreted by developing themes from the research questions. When overarching themes and categories were identified, they were used as the basis for further analysis and discussion. The raw data was then sorted into themes through word analysis, text review, and linguistic analysis.

In addition to applying the horizontalization approach, the interview data was independently read and coded according to open-coding techniques (see Appendices A & B) which Creswell (2007) described as "taking data . . . and segmenting them into categories of information" (p. 240) to organize the different themes that emerged from the collected data. That was accomplished by conducting a search for both words and phrases through reading the transcripts and highlighting themes. That uncovered a number of meanings related to the participants' experiences with online technology that constituted the invariant constituents of lived experience as noted by Creswell (1998). The researcher then inspected the interviews of six ODL electrical apprenticeship instructors, analyzed documents, and reviewed the online program shell to triangulate interpretations.

Coding techniques were also used to help sort the field notes and multiple case study data was analyzed through triangulation to identify potential problems of validity and reliability (Yin, 2003). The use of multiple data-collection methods and triangulation was critical in attempting to obtain an in-depth understanding of the effect(s) in the study.

In addition to the thematic analysis, this multiple case study incorporated cross-case analysis, development of a case description, and an examination of explanations. For the within-case analysis, each case was treated as complete in and of itself. Miles and Huberman (1994) suggested that data analysis processes included analyzing each interview transcription and identifying themes. Therefore, verbatim interview transcriptions were thoroughly examined and split into separate parts and categories further analyzed in a table. After themes were identified, the data were further analyzed to refine the themes into more specific categories. The table included each participant and each institution, using the research questions relating to the affordances and constraints of the online technology, kinds of social and physical environments, training competencies, implementation, and the student assessment and achievement levels.

Following the individual case study analysis, a comparative analysis using tables that showed all of the three cases was conducted. From the tables, I made cross-case comparisons between each instructor within each institution (i.e., cases) and all other instructors (Yin, 2003). Direct quotations exemplifying major themes from each participant were identified for use in the documentation which provided real-life examples and rich details relating to the specific research questions. Quotes from individual instructors were identified to validate the categories. Cross-case analysis provided ways to learn more about the themes and patterns across and between the three institutions and to deepen "understanding and explanation" (Miles & Huberman, 1994, p. 173).

The data analysis process included organizing and recording data using both Microsoft Word and Excel as well as the Atlas.ti qualitative computer software programs. Word, Excel, and Atlas.ti were utilized to manage and analyze interviews by aiding in storing, accessing, creating a visual model of, and retrieving memos associated with data. Use of Excel made the amount of data manageable and ensured that there were limits and parameters to the study.

Reliability and Validity

As the researcher, I was sensitive to the biases inherent in the case studies when I documented the interviews to meet the criteria of credibility and validity through member checks (Merriam, 2009). Member checks were conducted after the interviews were completed to review the transcriptions. In addition, instructors reviewed the researcher's interpretation of certain issues discussed from the interview.

Multiple case studies were used in order to learn "from single cases" (Stake, 1995, p. 85). According to Yin (2009) the three ways to verify data for case studies included construct validity, external validity, and reliability. Yin (2009) suggested that case studies' validity could be strengthened through using multiple sources of data. In addition, multiple sources of data also enhanced external validity (Merriam, 2009; Yin, 2009). Three cases with a total of six interviews of ODL apprenticeship instructors were employed in this research. Yin (2009) suggested that protocols should be developed for collecting data in case studies to ensure reliable procedures for each case with repeatable results. Therefore, in the study a modified version of Scagnoli et al.'s (2009) steps for data collection was followed which established data triangulation. Yin (2009) noted that triangulation of data was an accepted method for verifying results; therefore, the research included three sources of data, including interviews of ODL electrical apprenticeship instructors, document analysis, and a review of online materials such as the institution's website and the program course shell.

After each transcription, a member check was used to verify the participants' data (Stake, 1995). The instructors were given an opportunity to review the transcripts and verify their accuracy. Participants were asked to review the transcription after the interview and add, expand, and/or delete information, thereby validating the truthfulness of the interview process. Denzin and Lincoln (2003) described this process as the most critical test for verifying data and interpretation.

Ethical Considerations

Ethics approval for this research study was granted by the chair of the Conjoint Faculties Research Ethics Board (CFREB) at the University of Calgary on February 9, 2012. Participation in the study was completely voluntarily and participants were employed at their institutions at the time the research was conducted. All instructors were provided with informed consent forms and detailed information concerning their involvement in the study. The consent form also confirmed that their participation would remain confidential and that their organizations would also remain anonymous. All responses given during the interviews were recorded and securely stored in the researcher's home. Every effort was made to avoid using coercion to influence participants' responses in any way. The interviews took place during agreed-upon times that did not appreciably detract from planning, instructional, or personal time.

The researcher abided by ethical principles provided by the Tri-Council Policy Statement (1998). The research adhered to all requirements of the University of Calgary research ethics approval protocol concerning the ethics of research on human participants and included as many participants with diverse backgrounds as possible in an effort to ensure a reasonable attempt at equality and fairness.

Limitations

According to Yin (2003) case study research had limitations, particularly with multiple case studies. A single case study offered fewer opportunities to create generalizations to other cases and participants. Research case studies were designed not only to provide scientific generalizations to a specific population, but also to be “generalized to theoretical propositions” (Yin, 2003, p. 10). The use of multiple case studies for the research study was preferred over a single case study methodology because of the rich data collected.

Another limitation was that the researcher was not known in the electrical apprenticeship trades training field. Not having sufficiently strong connections with institutions across the nation may have made it difficult to find enough participants to participate in the research. The geographic, experiential, and vocational criteria for participants presented a problem as it became difficult to establish a fair sample for all apprenticeship trades programs delivered in an ODL format in Canada.

A limitation within the study was the intrinsic bias of the participants. Since the research focused on instructors who had already designed, developed, and taught ODL in the electrical apprenticeship trades, the sample was limited, and there were likely intrinsic biases that influenced these instructors. Given that the instructors were participating in ODL for the electrical apprenticeship trades training, they were biased in its favor. The bias could come either from instructors with good experiences or from those with bad experiences in designing, developing, and teaching ODL electrical apprenticeship programs.

Given that the electrical apprenticeship training community was small, the identities of the participating institutions and instructors were not disclosed. Protecting the anonymity of the participants and the organizations was an important element in gaining their participation in this research study. Protecting the anonymity of the institutions was challenging and limiting. Identifying the institutions as Canadian as opposed to identifying them in relation to a province or a region served to increase protection of anonymity. Since there are two provinces engaged in ODL for the electrical apprenticeship trades, in this study there was no attempt to address the experience of instructors in other trades disciplines using online learning for apprenticeship.

Delimitations

The study was delimited to instructors who designed, developed, and taught electrical apprenticeship training programs in Canada. All participants were carefully selected based on their experience teaching ODL and face-to-face electrical trades apprenticeship courses. The research might not be applicable to apprenticeship trades education generally or to ODL applications in other types of higher education programs. This study was delimited to the exploration of apprenticeship trades education in Canada so results might not be universally transferable.

The ODL format for apprentice trades education was relatively new and, as a result, many institutions offering apprenticeship trades education have not yet embraced nontraditional forms of training. Instructors' involvement with online class activities (including using learning management systems) varied in terms of the available technology at the institution as well as with student enrolment. Although trends for apprenticeship in Canada have been reviewed, the focus for this research was limited to electrician apprenticeship trades in Canada.

Research Reflection

The research had some challenges at the beginning, such as finding an ODL electrical apprenticeship program that was being offered at the time that the research was conducted, locating enough ODL electrical apprenticeship instructors interested in participating in the study, having institutions which initially offered ODL electrical apprenticeship programs withdraw after granting ethics approval, and the researcher's working environment work load increasing, thus slowing down the project. Conversely, many things worked well: there were no problems with any of the ethics application approvals for all institutions, the participants were very accommodating and passionate with their work in ODL electrical apprenticeship trades training, all of the participants provided great real-life examples in their interviews, the researcher was able to see each participant in-person which allowed for observation in how they used the LMS technology and simulations, there was quick feedback from each of the participants in the member checks, and there were no problems with any of the questions during the interviews.

Summary

This qualitative research study applied case study methodology to examine and understand both the affordances and constraints of online learning technologies used by instructors in distance learning environments within the context of electrical apprenticeship trades education programs. Interviews were conducted with six instructors from three public institutions. Data were analyzed using established principles of qualitative data analysis, while quality and verification were addressed through rich, thick description; peer review; and member checks. Chapter Four included a detailed account of the data collected from each of the cases.

Chapter Four: Individual Case Analysis

In Chapter Four the context and data collected is described for each of the case studies. In the beginning of this chapter, a demographic summary of each of the cases and the instructors was presented. In addition, each case was comprised of an overview of factors contributing to the affordances and constraints of online learning technologies used by instructors in distance learning environments within the context of electrical apprenticeship trades education programs.

To better understand the impact of online technologies in online distance learning (ODL) environments, the design of activities that rely on educational technologies was analyzed and the efficacy of those activities was then evaluated (Fretwell, 2003; Scanlon & Issroff, 2005; Mwanza & Engeström, 2003). The research focused on activity theory's mediating role in the context of explaining how people use computer technology (Kaptelinin & Nardi, 2006, p. 270). The five activity theory principles were applied to analyze the design, development, and teaching experiences within an educational setting for ODL electrical apprenticeship programs (Issroff & Scanlon, 2002). Those principles included the hierarchical structure of activities; the social and physical aspects of the online learning environment; the learning, cognition, and articulation of online activities; the development of online activities; and the zone of proximal development (ZPD) of online activities.

Case Study Demographics

The study involved three cases with six instructors in two Canadian provinces. The demographics of each of the participants were presented in Table 4-1. In the study all instructors were male, with an average age of 52.3 years. All instructors were working full-time, teaching online distance electrical third- and fourth-year apprenticeship programs. They were all master electricians and the majority of the instructors had some form of higher education. One instructor had a Doctorate in educational technology and two had Master's degrees in education. Among the instructors, the average time spent teaching face-to-face electrical apprenticeship programs was 11.5 years; for teaching online distance electrical apprenticeship programs, 10.4 years; and for designing and developing online curricula, 9.3 years. The educational technology used personally and professionally amongst all of the instructors included mobile communications, simulations, video games, and digital story-telling. The most common technologies used both personally and professionally were mobile communication and simulations. The technologies used by instructors may have contributed to community acceptance.

Table 4-1

Case Demographics

	Case Study One	Case Study Two		Case Study Three			Avg.
Name	Nike	Amp	Watt	Gorge	Current	Power	
Age	57	58	41	57	49	52	52.3
Gender	Male	Male	Male	Male	Male	Male	--
Employment Status	Full-time Instructor	Full-time Instructor	Full-time Instructor	Associate Dean	Full-time Instructor	Full-time Instructor	--
Highest Education	Master Electrician	Doctorate	Master Electrician	M.Ed.	M.Ed.	B.Sc.	--
Years Teaching Face-to-Face Electrical Apprenticeship Course	5	20	11	10	2	21	11.5
Years Teaching On-ine Learning Electrical Apprenticeship Course	13	3	1.5	15	15	15	10.4
Years Designing and Developing Online Curriculum	15	3	1	15	12	10	9.3
Technology Used Personally and Professionally	Mobile, simulations		Mobile, simulations, social networking/ media	Mobile, simula-tions	Mobile, simulations, video games, digital story-telling	Mobile, simula-tions, VR, video games	--

Case Study One Overview

Case Study One (Institution One) was based on three data sources including interviews of one ODL electrical apprenticeship instructor, document analysis, and a review of online materials such as the institution's website and the program course shell. According to the Institution One website, it offered many programs, including apprenticeships, for over 25,000 students. Further information on the website indicated that online learning began as a project with the goal of transferring some of the current apprenticeship training to an online format to relieve the burden on Human Resources departments, apprentices and employers. Institution One's online learning model for apprenticeship programs has served over 800 apprentices. Their approach to education is to engage learners in new ways in order to apply knowledge and skill. Education was integrated with community building and economic development.

Nike stated that there were two types of delivery for the electrical apprenticeship programs at Institution One. The two electrical apprenticeship delivery models for third-year apprentices were online and in-class, face-to-face classes. Nike, who had worked in the electrical trades as a master electrician for approximately 25 years and taught face-to-face electrical apprenticeship programs, was hired specifically to develop and deliver Institution One's ODL electrical apprenticeship program model.

In developing the program, Nike's goal was to design it to be similar to the face-to-face one with several differences. For the third and fourth years of theory training, there were a total of thirteen 30-hour courses, compared to twelve 30-hour and one 60-hour in-class, face-to-face course. Students had up to three months to complete each course in the online format.The online program did not include on-campus laboratory time as did the face-to-face program. The practical, hands-on laboratory portion for the third-year electrical apprenticeship program was self-paced, and it had open entry and open exit times. There was no limit to the number of students who could enroll in the third-year electrical online apprenticeship program. The skills competencies were recorded within each student's log book and the apprentice's employer signed off the student's hands-on practical skill competencies log book in both online and in-class courses.

The cost/tuition for the online and the face-to-face program was equal for both delivery models. Table 4-2 shows a comparison of the different electrical apprenticeship program delivery models offered at Institution One.

Table 4-2

Institution One Electrical Apprenticeship Program Delivery Model Comparison

	Case Study One			
	Online Model		**Face-to-Face Model**	
	Theory	**Practical (hands on)**	**Theory**	**Practical (hands on)**
Type of Delivery	Online distance learning	Employer (no classroom or laboratory)	In-class (classroom)	In-class laboratory
Max. Students	No limit	No limit	15 students per class	15 students per class
LMS	The Learning Manager® (TLM),, Blackboard ® Collaborate (Elluminate *Live!)*	--	--	--
Number of Weeks	3 months for each 30 hour course. Self-paced (open entry and exit). Thirteen 30-hour courses each	No formal practical training (must be completed before writing the IP exam) as the training was done by employer who signed off	Twelve 30-hour and one 60-hour course	14 weeks (including theory and practical)
Competencies Assessment	Minimum 70% on provincial final exam after each course completed	Completion of assignments in log book (signed and witnessed by the employer)	Minimum 70% on provincial final exam after each course completed	Completion of assignments in log book (signed and witnessed by the employer)

Nike said that the third and fourth year, face-to-face, electrical apprenticeship program's yearly training was 14 weeks long and included hands-on activities and theory (the institution did not separate the two). The maximum number of students enrolled in a given third-year electrical face-to-face apprenticeship class was typically 15. The third and fourth year face-to-face electrical apprenticeship program students did some practical, hands-on skill exercises and labs instructed by the employer or other journeyperson who signed off the student log book skills portion.

During the development period of the full online electrical apprenticeship program, other face-to-face, on-campus electrical apprenticeship instructors and electrical industry personnel reviewed the online program and suggested changes. In its final form the ODL electrical apprenticeship program ensured that students were prepared to write their final Inter-Provincial (IP) exam. The provincial Apprenticeship Board required that all apprentices write the final multiple choice exam at the end of their apprenticeship. In order to pass the fourth year, students had to achieve a minimum 70% on all review tests and the IP exam.

According to Nike, the learning management system (LMS) technologies used in the ODL electrical apprenticeship trades programs at Institution One are Elluminate *Live!* and The Learning Manager® *(*TLM*)* software. Nike found Elluminate *Live!* to be a "very well-developed tool for teaching online" that allowed him to set up synchronous sessions in the evening. Live chats were available in the evenings using Elluminate *Live!* and web tours which allowed him to see the students' responses. In addition, Nike said he often shared applications relevant to the problem or activity on his computer. Nike usually recorded each session and sent students the link to facilitate their review. He reported that this practice was helpful for online students.

Among the activities Nike reported using in the ODL electrical apprenticeship program at Institution One was a motor starter exercise that allowed students to become familiar with the location of the controls on the actual device. In another activity Nike provided a series of recorded sessions on how to use the Canadian Electrical Code. Students could watch these pre-recorded sessions as often as they wished.

Principle 1: Features Contributing to the Hierarchical Structure of Activities

Two key features which contributed to the hierarchical structure of activities included the functions of ODL technology and limitations of ODL technology.

Functions of ODL technology. At Institution One, Nike reported that audio was used quite frequently with a live or a stationary picture. Many presentations were recorded and a whiteboard was used. Sometimes Nike used web tours, application sharing, and, if the sessions were synchronous, the chat feature (with microphones muted). Although they enhanced the classroom activity, videos were seldom used due to their file sizes, which required too much memory and bandwidth space.

Limitations of ODL technology. At Institution One, the lack of practical, hands-on experience to reinforce the theory was perceived as a limitation in using ODL technology in apprenticeship trades training. Nike mentioned that while a simulation could complement theoretical knowledge of a procedure, there was no substitute for a student actually performing the task. For example, apprentices learning to install signalling devices in a fire alarm system needed to read trouble signals that appeared in the real world situation but which were not present in the ODL environment.

Principle 2: Social and Physical Aspects of the Online Learning Environment

Five key social and physical aspects of the online learning environment were identified, including the benefits, availability, and integration of ODL technology and the characteristics, rules, and regulations of ODL apprenticeship programs.

Benefits of ODL technology. Nike thought that an online learning environment was particularly appropriate for students who were self-motivated and who had good comprehension skills. The technology allowed students to take all their courses online (except for the final exam) and receive their certifications without leaving home. Thus, their training did not disrupt the students' work or disadvantage their employers. The technology also allowed students to work at their own pace. Nike said he had taught the 30-hour, one-week, on-campus classes and watched students struggle with being away from work and family. In that type of program, students were in a face-to-face classroom from Monday to Thursday and then were tested on Friday. For some students that was not enough time and for others it was too much. Therefore, the self-paced aspect of the online learning environment was an important part of the electrician apprenticeship program.

Availability of ODL technology. At Institution One, the platform available within the online learning environment included TLM and Blackboard® with Elluminate *Live!* Simulations, animations, and other online web resources were available, but Nike reported that it was very time-consuming to receive copyright permissions for online use. Nike explained that he was able to get permission to use Client Tools for his online presentations since the institution did not charge the students to use Client Tools.

Integration of ODL technology. According to Nike, Blackboard allowed him to integrate Adobe or MS Office files with other tools and technology, such as importing

PowerPoint presentations into Blackboard and then saving them as files within Elluminate *Live*. Elluminate *Live* allowed him to edit the files and add drawings. If a part of the electrical code stored on a CD needed to be shared with the classroom, the instructor imported it into Word or PowerPoint. In conducting web tours Nike took students to an interactive site through Blackboard. The website Nike often used had interactive parts such as transformers and AC/DC generators. Students could change the frequency and see what happened to the transformer. If the students added a turn on the primary side of the transformer, they could see what happened to the open voltage on the secondary side. While the students were on the website, he made changes to the simulations such as the voltage on a transformer simulator.

To help teach students Lenz's law, a learning goal for the apprenticeship program, Nike used an interactive activity available on the Molecular Expression website. This interactive website was integrated with Blackboard. The students moved a virtual magnet or a piece of wire within a magnetic field and could see the collapsing fields, how magnetism generated electricity, and the way iron filings formed around the ends of magnets. The site also included activities related to electronics.

Characteristics of ODL apprenticeship programs. At Institution One, the face-to-face apprenticeship trades training was designed to be similar to online apprenticeship trades training. According to Nike, some activities in the online technology environment were initially designed for the face-to-face classroom, but the volume of material was changed for online use based on what instructors could deliver in a 30-hour course. In cases where the material would not fit into a 30-hour course, it was expanded into two 30-hour ODL courses.

One of differences between face-to-face and online instruction at Institution One was that online activities were distributed asynchronously. If needed, the ODL instructor provided material on a one-on-one basis with the students through live, synchronous, online sessions. These sessions were primarily reserved for students who were experienced with the technology. Nike further explained that the online, synchronous sessions were mainly available for the provincial (IP) refresher students. Several instructors ran two or three different IP refreshers online.

Rules and regulations for ODL apprenticeship programs. According to Nike, the funding for the online learning program development was from the provincial government which provided the curriculum for the electrical apprenticeship trades. Nike explained that the program was expected to cover the electrical topics and meet the outcomes within the timeframe set by the provincial government. The government packaged the provincial curriculum documents so that the institution could acquire them at a reasonable cost. The province allowed plenty of flexibility for the delivery of the curriculum and did not stipulate what type of activities should be used to teach the curriculum.

Principle 3: Components Contributing to Learning, Cognition, and Articulation of Online Activities

Five components contributed to the learning, cognition, and articulation of online activities: learning conflict with ODL objectives, learning in an ODL environment, access to ODL, learning representation, and pilot for ODL apprenticeship programs.

Learning conflict with ODL objectives. According to Nike, there were very few differences between face-to-face and online learning objectives that might lead to conflict in understanding concepts. Nike explained that the online program’s objectives or outcomes set up in the base outline and approved by the province were basically the same as those for the face-to-face program.

Learning in an ODL environment. According to Nike, the amount of time and effort devoted to learning to use the online technology impacted the students' learning. Younger students who had grown up in the computer age were very computer proficient, but some of the older students who were taking online courses needed help with the technology. Instructors encouraged these students to persist through two courses, after which they usually had developed a better understanding of online technology. Nike explained that many activities within the electrical apprenticeship online program were designed to be point and click in order to accommodate students without sophisticated computer skills or strong typing skills. This minimized the learning curve for all students. Furthermore, the material in the online learning environment was restricted to what students needed to know to pass the final provincial exam. In addition to online material, there were additional provincial materials such as printed modules which students required in order to complete the online activities available through the Institution's bookstores.

Learning representation. The online learning environment at Institution One facilitated self-evaluation through the use of a 20-question review test. Nike explained that after the students read the material and completed the study questions for that particular topic, they took a 20-question review test on that topic. The students were given a couple of attempts to get 70% of the answers correct. Nike noted that this evaluation was a nonproctored test. It allowed students to assess their comprehension and their readiness to write their graded final exam. When students needed help, they simply emailed the instructor.

Pilot for ODL apprenticeship program. According to Nike, the pilot for the online distance apprenticeship training activities was the industrial electrician's online program. None of the students had their industrial tickets and their goal was to write and pass their IP exams.

Generally the students enrolled and the instructor monitored them. The IP results were a gauge of how the online students fared compared to students in the in-person class. If there were problems, the programs were modified.

Principle 4: Factors Contributing to the Development of Online Activities

Three key ODL design factors contributed to the development of the online apprenticeship trades training program at Institution One. The contributing factors included implementation of ODL technology, apprenticeship community attitude toward ODL apprenticeship programs, and apprenticeship community barriers to ODL apprenticeship programs.

Implementation of ODL technology. According to Nike, the effect of the implementation of online technology for the apprenticeship trades program was minimal. The ODL format focused on theory and no changes were made to the curriculum. However, recently, the face-to-face classroom has become more project-based while the online course has remained theory-only. Nike further mentioned that when the ODL electrical apprenticeship program started, other instructors felt threatened. Ironically, the head of the department did not understand why those instructors felt that way; in fact he commented that in his experience, whenever online training programs were developed, the number of students in face-to-face programs also increased which increased instructor teaching opportunities. There were negative feelings from other instructors when administrators at Institution One began to discuss developing an online program. Sometimes when the face-to-face instructors heard that a course for online delivery was being developed, they felt that their livelihood was under attack. Nike explained that three electrical instructors developed the electrical apprenticeship program. After the program was implemented, the number of instructors in the electrical department increased to seven and included both face-to-face and online instructors.

Apprenticeship community attitude toward ODL apprenticeship programs. According to Nike, the apprenticeship community was initially sceptical about ODL apprenticeship programs. He provided as an example the opinion of one person who had been in the electrical union: “You can’t teach an electrician on a TV set.” Other than the pushback from some instructors, the rest of the apprenticeship community was in agreement by the time the program was developed. Subsequently, the apprenticeship community supported the online electrical apprenticeship program due to the demand for skilled technicians.

Apprenticeship community barriers to ODL apprenticeship programs. According to Nike, there were few internal or external barriers to using online technology in the electrician apprenticeship program. For example, instructors were treated equally in the work environment with the exception of the flexible schedules for online instruction even though the students worked from home and only came to campus to write a final exam.

Nike explained that the apprenticeship community favored allowing students to attend a face-to-face session if they missed a course. This flexibility presented a few problems in the classroom because some of the courses had more material than others. Therefore, there was pushback from the classroom instructors when Institution One offered online apprenticeship courses because some of the courses had too much material for a 30-hour week. The instructors at that time responded by splitting some of those courses and made them into two 30-hour online courses. This helped the instructors to keep the course material consistent. Nike noted that it was important to the provincial apprenticeship board to have both online and face-to-face courses structured similarly to accommodate students’ needs.

Principle 5: Components Contributing to the Zone of Proximal Development of Online Activities

Two components for enhancing student learning within the ZPD were identified through the data analysis: assessment in ODL apprenticeship learning environment and scaffolding in ODL apprenticeship learning environment.

Assessment in the ODL apprenticeship learning environment. According to Nike, the provincial apprenticeship board dictated the multiple choice final exam's standard questions. The online test banks were set up this way so that the marking would be objective. Nike further explained that online courses did not require essays or reflections, as happened in the face-to-face classrooms. As well, there were no project presentations as in the face-to-face classrooms. Nike noted that the limitations included the types of exams, project presentations, written papers, and the ability to test verbally.

Scaffolding in the ODL apprenticeship learning environment. According to Nike, scaffolding strategies used to enhance learning included asking students to complete study questions on reading material. Students simply jotted down their answers as they went through the material. By doing that, they reinforced their learning and made study notes on important topics.

Case Study Two Overview

Case Study Two (Institution Two) was based on three sources of data including the interviews of two ODL electrical apprenticeship instructors, document analysis, and a review of online materials such as the Institution's website and the program course shell. According to the Institution Two website, it offered programs from "apprenticeships to baccalaureate degrees . . ." With a focus on experience-oriented training that provided students with the skills they needed to find high-quality jobs, polytechnics were also committed to working closely with industry to promote applied research and innovation. Institution Two's website noted that it has been in operation for over 70 years and that it provides training to more than 70,000 registrants annually in over 30 apprenticeship programs.

According to Amp, there were two ways in which the electrical apprenticeship programs at Institution Two were delivered. The two electrical apprenticeship delivery models were blended (online and in-class) and face-to-face (in-class) models. Amp explained that the up-front costs for the student were the same for both models and involved the registration and materials. Amp said that the flexible format had proved to be a more cost-effective mode of study for the students because it prevented the lost wages, employer down time, and lost hours that were associated with required in-class time. However, Amp noted that the up-front costs for blended delivery were much higher initially than were those for face-to-face delivery. The development of the LMS Desire2Learn® (D2L) shell was extensive and the designing of self-directed materials involved an additional expense. However, once the materials were developed, the managing of the program was split off to provide all students with a resource repository for review and study purposes.

Amp said that the theory portion of the third- and fourth-year, face-to-face program was interspersed with the lab component throughout the program. The third-year program lasted for eight weeks, while the fourth-year program lasted for 12 weeks. The third-year program had 112 hours of theory supplemented by 80 hours in the laboratory, while the fourth-year program had 96 hours of theory with 168 hours in the laboratory. Amp explained that the theory and laboratory portions were usually taught in the same room so that the hands-on experience occurred as closely as possible to the presentation of the theoretical information. The labs or experiments were designed to connect hardware in order to verify the concepts presented in the theory class. Table 4-3 shows a comparison of the different electrical apprenticeship program delivery models offered at Institution Two.

Table 4-3

Institution Two Electrical Apprenticeship Program Delivery Model Comparison

	Case Study Two			
	Online Model		**Face-to-Face Model**	
	Theory	**Practical (hands on)**	**Theory**	**Practical (hands on)**
Type of Delivery	Online distance learning	In-class experiments/laboratory	In-class (classroom)	In-class experiments/laboratory
Maximum Students	Cohort group of 16 students per instructor	Cohort group of 16 students per instructor	Cohort group of 30 students in the 3rd year classes and 24 in the 4th year classes	Cohort group of 30 students in the 3rd year classes and 24 in the 4th year classes
LMS	D2L as the LMS TLM as exam drills and practice exams.	--	D2L as the LMS TLM as exam drills and practice exams.	--
Number of Weeks	3rd year period had a total of 16 weeks (both theory and practical), with 12 weeks allotted for the online theory 4th year period had a total of 21 weeks (both theory and practical), with 16 weeks allotted for theory	3rd year had a 4-week campus lab component. 4th year was a 5-week campus lab component.	3rd year period, 8 weeks; 4th year period, 12 weeks 3rd year has 112 hours; 4th year has 96 hours	3rd year period, 8 weeks; 4th year period, 12 weeks 3rd year had 80 hours; 4th year had168 hours
Competencies Assessment	Minimum 70% on provincial final exam after each year completed	Practical skills taught on the job site Campus labs support the theory (signed and witnessed by the instructor)	Minimum 70% on provincial final exam after each year completed	Practical skills taught on the job site Campus labs supported the theory (signed and witnessed by the instructor)

Amp explained that the face-to-face program had a cohort of 30 students in the third-year classes and 24 in the fourth-year classes. The practical skills were taught on the job site. As for the blended learning model, Amp noted that they had a system in which the students in both the face-to-face and blended programs dropped in when they had the time and applied the online learning to the lab experience. This was changed to fixed times for theory and lab. Amp explained that the third-year blended program lasted for 16 weeks, with 12 weeks allotted for the online theory portion and four weeks for the lab component. The fourth-year program lasted for 21 weeks, with 16 weeks allotted for the theory component and five weeks for the lab component. Amp noted that the labs or experiments for both the face-to-face and blended models were designed to augment the theory portion of the electrical apprenticeship program. The lab (practical) exams were paper and pencil tests to determine if students understood the concepts. The student's grade on the practical exam was recorded as a separate mark which was reported to the provincial government.

As in the face-to-face program, Amp said that the blended program student enrolment was limited to a cohort size of 16 students. In both the blended and face-to-face electrical apprenticeship programs, the students were on a fixed entry and a pseudo open exit. All students had to attend the lab component at the end but they were allowed to exit early when they had completed all of the labs.

The curriculum goals and sub-goals for the electrical apprenticeship program were established by the provincial Industry and Trade Ministry. The province established learning objectives and developed individualized learning modules (ILMs). In response to the provincial mandate, Amp, the primary architect of the ODL electrical apprenticeship program, and Watt, who provided feedback relating to electrical codes, designed a 21-week ODL program that used blended learning techniques (the theoretical component was online, and the laboratory/practical component was on-campus). The practical component lasted for approximately three weeks. The program prepared students to take the annual Trades Qualification (TQ) exam as mandated by the provincial Industry and Trade ministry. In the fourth year, students took the Red Seal IP exam in addition to the TQ exam. The Red Seal exam allowed the electrician to practice in any Canadian province or territory.

According to both Amp and Watt, the online electrical apprenticeship program was designed around the individual learner and the provincial ILMs. Consequently, the program was self-paced and students' progress was monitored. If students had difficulty making adequate progress, they could: (a) attend the on-campus course at least two days per week, accessing the ILMs every day and qualifying for Employment Insurance, (b) attend full-time as on-campus, face-to-face students for the last five weeks; or (c) withdraw from the electrical apprenticeship program.

Amp noted that the online program also was designed to accommodate the learning styles and needs of electrician apprentices who were very tactile, visual learners focused on gaining immediately applicable, practical skills. These learners expected to transfer their knowledge directly to the job site, where the journeyman became a part of their learning system. Therefore, instructors at Institution Two designed interactive, multimedia activities using proprietary Mediator software and they integrated laptops and tablets into the curriculum. An electrical, hands-on, face-to-face, on-campus laboratory was set up to include online students. The type of activity was based on which technology allowed the students to meet the learning objectives and goals. For example, drag-and-drop interactive animations with exploded views were employed to simulate taking apart DC generators and control circuitry.

Watt described how students used the Mediator software to calculate the size of the main electrical service connection for a facility which depended on the type of occupancy. The problems got more difficult as the students progressed to specifications of different electrical permits and different types of buildings. The Mediator software performed the calculation and provided the students with instant feedback. According to Watt, the principles of rotating electrical machines could also be visually displayed in the virtual ODL environment. The students followed the process for diagnosing the equipment and answered questions throughout the process. If they got the wrong answer, the software prompted them to review information. The animations included realistic graphics, videos, and the recorded voice of the instructor. Further animations clarified confusing issues such as meter equipment reading discrepancies.

According to both Amp and Watt, student progress was tracked through TLM; however, the institution planned to change its learning management system (LMS) to D2L in the near future. The D2L would be used as a test bank similar to TLM and a multimedia training guide for the students. It included MS PowerPoint-based tutorials, interactive videos, a frequently asked questions (FAQ) section, an electrical code review with sections of codebook, and quizzes.

Principle 1: Features Contributing to the Hierarchical Structure of Activities

Four key features contributed to the hierarchical structure of activities: the functions of ODL technology, limitations of ODL technology, apprenticeship community conflict with ODL programs, and apprenticeship community influence on ODL programs.

Functions of ODL technology. According to Amp, the collaboration function of the D2L, which allowed students to interact with other students, was not used. Amp said that the last thing apprentices needed was to have somebody tell them "Well, today you will submit a 10-page report and then we will all discuss it." If a student had problems, those questions were emailed to the instructor who addressed them in the TLM. Amp stated that the students by their own choice generally did not engage in chats or establish collaborative relationships. According to Watt, the students were “very individualistic.”

Amp noted that the online technology had features that were not supported by the learning activities. For example, a Flash animation could be used in the LMS for students with various types technologies such as smartphones or tablets. Amp stated that the goal was to allow students to access it without any technical problems.

Limitations of ODL technology. Watt said that the students complained that the D2L software was not very user-friendly. According to Watt, some of the students said, “Wow, had I known this, I would never have taken the program,” or “I would never have agreed to enrol in it.” Although this was not related to technology but rather a shortcoming on the part of the instructor, the students felt overwhelmed by the quantity of material they had to learn in 21 weeks.

Apprenticeship community conflict with ODL programs. According to Amp, the primary conflict between the face-to-face instructors and online instructors was the mental shift involved in changing from a system where instructors were given a structured class timetable to one in which they were assigned hours and were responsible for setting their own schedules around an open classroom. Institution Two assigned only 656 hours per instructor and how they managed the laboratory was up to the instructional group.

Apprenticeship community influence on ODL programs. According to Amp, the apprenticeship community influenced the design of the online apprenticeship program in that it addressed the skills shortage and workforce needs. The provincial government was extremely supportive in terms of funding once it became aware that, as Amp described it, “the course is not only connected to the student community. The outcomes of this program have been phenomenal in terms of student satisfaction, in terms of student life, in life balance (work, income, family)." Amp and Watt both noted that Institution Two was contracted to provide technical training so that the students could qualify to perform tasks or gain the skills necessary to satisfy the minimum requirements for the provincial trades qualifications.

Principle 2: Social and Physical Aspects of the Online Learning Environment

Based on analysis of the interview data and documents, eight key components of the social and physical aspects of the online learning environment at Institution Two were identified: the concepts and vocabulary of ODL, importance of ODL technology, availability of ODL technology, integration of ODL technology, characteristics of ODL apprenticeship programs, spatial layout of the ODL environment, rules and regulation for ODL apprenticeship programs, and resources for ODL apprenticeship programs.

Concepts and vocabulary of ODL. At Institution Two, the concepts, general vocabulary around the ODL program, and the technology were explained during a student orientation session. According to Amp, the concepts and vocabulary of online apprenticeship courses were relatively consistent with those of face-to-face courses since the online distance electrical program was not intended to be totally different from what students were experiencing in the face-to-face classroom. Amp explained that the vocabulary was virtually the same and the terminology was standard industry terminology; any challenge with vocabulary was related more to the fact that the terminology used in the educational environment could be foreign to students.

Importance of ODL technology. Online technology, according to Amp, affected apprenticeship training due to the type of information conveyed. He described apprentices who were familiar with many different devices such as smartphones and other digital media. The technology allowed them to access a much higher level of information such as manufacturer specifications and online electrical simulation programs. Both Amp and Watt suggested that the technology was embraced slowly by the apprenticeship community probably because the apprentices were very tactile and interested in practical application of knowledge. The online learning community, according to Amp and Watt, attracted these types of learners because they found sufficient stimulation, applied their knowledge, and sidestepped classroom discipline.

Amp believed that, in contrast to their counterparts of 20 years ago, contemporary apprentices sought more flexibility to accommodate their family, lifestyle, and work responsibilities. Thus, they have put a burden on the employers, society, and training institutions to devise a program that was more suited to their needs. The program at Institution Two had attempted to meet the needs of contemporary learners, who, as Amp stated,

> are different now—they can get lectures off their iPhones. Similarly, the need to interact is different. It is not like when the student had to sit in a classroom, listen, and not speak—take the information, write it down, regurgitate. They listen and take it in.

Amp reported that some of the apprenticeship online learning activities had been distributed asynchronously and on occasion the apprentices were not really as concerned about the synchronous activities. Amp noted that the students did like immediate feedback from their instructors via email. Amp argued that the apprentices usually did not want to talk to the instructors, especially during the day when the instructors were in the lab at the same time.

Availability of ODL technology. According to Amp, Institution Two developed simulations that allowed a student to lay out an electrical panel, move a panel door, identify the outlets on the panel, and practice troubleshooting. Videoconferencing was used to share information visually. It was reported that it was almost like a face-to-face meeting over the Internet but that the Institution's Internet connection was not fast enough. Amp also noted that collaborative learning or discussion was not available for the students as it did not work well with the apprentices who were focused only on the material and the job in contrast to traditional higher education students.

Integration of ODL technology. According to Amp, the experience of Institution Two with online integration of technology started with the development of the program. The subject matter experts (SMEs) made sure that all the links worked and that everything was appropriate. In addition to the SMEs, other instructors reviewed the program and checked links, user-friendliness, and functionality.

Watt stated that many other full-time apprenticeship programs used D2L as a test bank system, but that the online requirements were specific to object-based apprenticeship programs and Institution Two's electrical apprenticeship program involved a significant amount of math. D2L did not support trigonometry functions. Both Amp and Watt agreed the TLM could handle custom questions, but Watt stated that this was not easy. According to Watt, the advantage with TLM was that it generated randomized questions for each test and provided immediate feedback.

Characteristics of ODL apprenticeship programs. According to Amp, activities initially designed for the online environment were also being used for the face-to-face apprenticeship learning. All the instructors in the face-to-face apprenticeship electrical program had access to computer tablets so they could wirelessly log into the D2L and pull up all of the interactive objects. Amp explained that students were exposed to a higher level of graphics, a much higher level of interactivity, and a much higher level of understanding of how systems worked by using what was developed online.

Amp stated that there were no differences between face-to-face and online learning objectives that could lead to conflicts in learning. Both programs had the same objectives, printed materials, provincial exams, basic criteria, and evaluations. Institution Two ensured that the online program was not watered down. The one difference was that fewer students worked in the lab—one or two versus 24 or 30 in a regular classroom. The student-to-instructor ratio was better in the face-to-face lab than in the online lab. Amp also noted that "none of these guys ever quit work . . . . They don't have to put their families in jeopardy."

Spatial layout of the ODL environment. According to Watt, the spatial organization of the online learning environment mimicked that of industrial environments. Watt explained that the students hooked up electrical equipment using little test leads. He argued that this could be achieved on the same scale in the industry because there was no room in the laboratory. However, Watt explained that the wiring method still involved hooking up the right wires to the right points.

Rules and regulations of ODL apprenticeship programs. According to both Amp and Watt, Institution Two had rules and procedures regulating social interaction and coordination related to the use of the online technology that were provided to the students during orientation. Amp noted that in terms of ethics and language, no problems with any students had been reported. Amp explained that the instructors made it very clear that that if students started engaging in inappropriate behavior online, the Institution would expel them.

Resources for ODL apprenticeship programs. According to Watt, the resources available to design and develop the online distance apprenticeship program included funding from the provincial government as well as from the learning community and the industry (i.e., large corporations, manufacturing plants, oil companies). Watt explained that persuading the industry to provide resources had been very difficult because it did not initially see the value of the program. Once the program was implemented, the apprenticeship community became more accepting.

Principle 3: Components Contributing to Learning, Cognition, and Articulation of Online Activities

Through the data analysis, three components that contributed to the learning, cognition, and articulation of online activities were identified. These included learning in an ODL environment, learning representation, and a pilot for ODL apprenticeship programs.

Learning in an ODL environment. Amp stated that the amount of time and effort needed to use the online technology impacted student learning. The online learning electrical apprenticeship program was designed to require minimal computer skills. Watt noted that utilizing the multimedia required some extra learning. Both Amp and Watt said that the goal was to facilitate students' use of the technology. Building multimedia was intended to allow students to perform complex calculations without having to learn specialized programming techniques. The D2L design focused on the hub and the learning modules were based on the course objectives. The students were to read the modules and then proceed to multimedia links.

Although Institution Two encouraged working with peers, Amp stated that there were no formal group activities within the online apprenticeship training curriculum. In situations with complex learning objectives, students could choose to work in groups with others.

Learning representation. Amp noted that the online learning environment he created was intended to help in self-evaluations through guided corrective feedback. Students used the online program to find solutions or request help from the instructor. The Institution had a 24-hour D2L help phone number which reduced the number of inquiries emailed to the instructor.

Pilot for ODL apprenticeship programs. According to both instructors, the pilot tests on the online distance apprenticeship training activities included a year's worth of pilots with three classes of fourth-year electrical apprentices. In 2011, Amp noted that there were two classes of third-year students who went through the pilot with extremely good results. The pilot test results included summative evaluations at the end. The maximum number of students in the pilot courses was sixteen as that was the capacity of the laboratory. The institution compared the results to those of on-campus students and looked at student retention. The costs for the online and face-to-face courses were found to be the same.

Principle 4: Factors Contributing to the Development of the Online Activities

Three key factors contributed to the development of the online apprenticeship trades training program at Institution Two. These factors included implementation of ODL technology, apprenticeship community attitude toward ODL apprenticeship programs, and apprenticeship community barriers to ODL apprenticeship programs.

Implementation of ODL technology. According to Watt, the online program had not greatly changed the electrical apprenticeship training because it was just in its second year of implementation. However, the implementation of the online learning environment did improve student screening for the program. The pilot process provided students with a better understanding of an online environment. Some of the students were very motivated and self-disciplined, while others were not. As a result of the pilot, changes were made to the D2L shell, including an expanded FAQ section and additional introductory material. The instructors had to think of every possible question a student might ask.

The instructors who were involved with program design had a great deal of expertise which resulted in very little extra training being necessary. Amp's Doctorate in education technology and Master's degree in education and his experience as an instructor in the electrical apprenticeship trades for 20 years contributed to the success of the ODL. The other two instructors had Master's degrees in leadership and were also key players in the development of the ODL electrical apprenticeship program. These three instructors developed the ODL program and combined their resources, together with the instructional design SMEs, to produce a learning structure, a learning design, to meet the needs of apprenticeship students.

Apprenticeship community attitude toward ODL apprenticeship programs. According to Amp, the prevailing belief was that apprentices must come up through the ranks as low-end workers until they became journeymen. Despite some individuals within the apprenticeship community's belief that online learning for the electrician apprenticeship trade was inappropriate, the apprenticeship community has generally recognized the success of the ODL program.

Apprenticeship community barriers to ODL apprenticeship programs. Amp claimed that online instructors and students felt that they were part of the school community. The instructors were hand-picked for their enthusiasm for a new teaching and learning method and were learning and developing the process on a continual basis. Amp explained that the students completed all of the labs that face-to-face students did and therefore they did not feel that they were singled out as advantaged or disadvantaged. Institution Two offered an orientation session to all of the online students that proved to be a valuable introduction to the program, the instructors, and their fellow students.

Amp described the conflicts as administrative barriers. For example, Watt said the course load was based on the fact that the collective agreement stipulated that instructors log 650 contact hours per year. The limitations included the definition of those contact hours which meant daytime hours. Watt argued that the electrical apprenticeship program included teaching on evenings and weekends which was not an option. This was perceived as being in direct conflict with the collective agreement. Amp noted that all staff were evaluated similarly: “The classroom that they’re teaching in—whether it’s on the facility or off the facility—is not what I look at. I look at their teaching ability with the students. So there’s really no difference, no animosity, no hierarchy, nothing.”

According to Watt, there were no significant clashes between the face-to-face and online instructors. The scheduling was governed by the collective agreement and only allowed face-to-face contact (i.e., labs) with the online students from 9:00 a.m.–3:00 p.m., five days per week. Every online instructor also had regular daytime classes, which presented a bit of difficulty in scheduling online lab time supervision. In Watt’s opinion, to be a fully accessible program, laboratory times needed to be extended into at least several evenings a week and one full day each weekend. As far as determining the attitudes of the other instructors, most of them, according to Watt, were indifferent toward or unaware of what really happened in the online blended learning courses.

According to Watt, the course had received preferential treatment from the Institute’s instructional designers for the past several years. The reason for this was that the online program was run as a pilot and only in 2012 became a regular core-funded program. Amp described management treatment of the instructors as being no different from that of the full-time course instructors. Students tended to favour the environment that allowed one-on-one instructor access.

Principle 5: Components Contributing to the Zone of Proximal Development of Online Activities

Two components for enhancing student learning within the ZPD were identified through the data analysis: assessment in ODL apprenticeship learning environment and scaffolding in ODL apprenticeship learning environment.

Assessment in ODL apprenticeship learning environment. Watt explained that in the design of the program, Institution Two tried to achieve certain course objectives, thus enhancing the ability of the student to tackle more complex problems and building from the first- through the fourth-year apprenticeship. When the students got to their fourth year, whether in the online or the full-time program, they were expected to have developed certain abilities and to have reached a certain skill level. Amp explained that students in the electrical apprenticeship program could successfully complete the entire program in 12 weeks online. Students wrote intermediate, basically formative, exams, as well as summative exams at the end, which prepared them for the IP exam.

Amp described the online distance electrical apprenticeship program as having formative evaluations at every stage. The students took an approximately 100-question exam at the end of each section. The final exam, the TQ exam, was also a 100-question exam. The online program was patterned after the TQ and prepared apprentices to write for the provincial government and the IP final exams.

Scaffolding in the ODL apprenticeship learning environment. Institution Two used scaffolding throughout the entire program to tie together concepts and theories. Amp explained that the adult apprentices wanted to learn something that was immediately applicable and that built on their previous experiences. In one electronics activity, for example, the first stage covered the very basic level of electronics—the basic understanding of diodes and rectifiers. At the next level students looked at applications of those concepts in equipment.

Case Study Three Overview

Case Study Three (Institution Three) was based on three sources of data, including the interviews of three ODL electrical apprenticeship instructors, document analysis, and a review of the online program shell. The ODL electrical apprenticeship instructors interviewed at Institution Three were Gorge, Current, and Power who taught electrical apprenticeship courses in the traditional face-to-face classroom for approximately 10, 2, and 21 years, respectively.

According to the Institution Three website, it opened in the 1960s. Its first class comprised under 30 communication electrician apprentices who started their training before the institution was complete. According to the website, Institution Three had grown to more than 200 credit programs enrolling more than 12,000 apprentices by 2012.

According to Gorge, Current, and Power, there were two ways in which the electrical apprenticeship programs at Institution Three were delivered. The two electrical apprenticeship delivery models were blended online and in-class face-to-face models. Gorge and Power noted that the cost/tuition for the blended online and the face-to-face program was regulated by the province and was equal for both delivery models. Table 4-4 shows a comparison of the different electrical apprenticeship program delivery models offered at Institution Three.

Table 4-4

Institution Three Electrical Apprenticeship Program Delivery Model Comparison

	Case Study Three			
	Online Model		**Face-to-Face Model**	
	Theory	**Practical (hands on)**	**Theory**	**Practical (hands on)**
Type of Delivery	Online distance learning	In-class experiments/laboratory	In-class (classroom)	In-class experiments/laboratory
Maximum Students	No limit. 20 students is the benchmark	12 students per instructor	24 students per instructor	12 students per instructor
LMS	TLM	--	TLM	--
Number of Weeks	3rd year period – 24 weeks, 4th year period – 36 weeks	3rd year period – 8 weeks, 4th year period – 12 weeks	3rd year period – 8 weeks, 4th year period – 12 weeks	3rd year period – 8 weeks, 4th year period – 12 weeks
Competencies Assessment	Minimum 70% on provincial final exam after each year completed	Observation of experiments (signed and witnessed by the instructor)	Minimum 70% on provincial final exam after each year completed	Observation of experiments (signed and witnessed by the instructor)

Power said that the theory portion, when delivered face-to face, lasted for eight weeks for the third-year period and 12 weeks for the fourth-year period; in contrast, the theory portion when delivered online lasted for 24 weeks for the third-year period and 36 weeks for the fourth-year period. As for the practical/hands-on portion delivered face-to-face, there was no direct practical/hands-on training, but there were “experiments/labs” associated with the theory portion of the course which could be completed within eight weeks for the third-year period and 12 weeks for the fourth-year period. However, the practical/hands-on portion for the electrical online blended apprenticeship program had no direct practical/hands-on training but, just as in the face-to-face model, there were “experiments/labs” associated with the theory portion of the course that also need to be completed within eight weeks for the third-year period and 12 weeks for the fourth-year period.

Power noted that the maximum number of students who could enroll in the third- and fourth-year period of the face-to-face, electrical apprenticeship program varied. For the lecture portion of the course there were 24 students to one instructor and for the laboratory portion where the students did the experiments, the ratio was 12 students to one instructor. However, the maximum number of students who could be enrolled in the third- and fourth-year online blended electrical apprenticeship program was 20. Students had to complete the lab experiments for all delivery models (ODL and face-to-face), and those experiments had to be signed/witnessed by the instructor before the students could complete their program. The students could enter the online blended electrical apprenticeship program any time after the beginning of the academic year (September) but the program had to be completed by mid-June.

The Provincial Advisory Committee (PAC) determined the curriculum and hours required for training based on the learning objectives that were set by the province's apprenticeship branch. The PAC was made up primarily of industry representatives and employers who were active in the electrical trade. One representative from Institution Three sat on that committee. According to Gorge, Current, and Power, while Institution Three had very little freedom to stray from the learning objectives, it had some flexibility in its mode of delivering course content. Gorge explained that Institution Three functioned as a "subcontractor to the provincial government" in delivering the curriculum.

All three instructors noted that Institution Three's goal was to create a flexible distance program for the learner. Gorge argued that this flexibility allowed access by people who could not afford to leave work to learn new skills. Distance students came from all across the province to train; a great number of students worked in the gas and oil industry where they might work in a remote location for two weeks and then be at home for one week. Institution Three's distance program accommodated these different schedules. Students who enrolled in the distance program signed a contract with the provincial apprenticeship branch and with the Institution that gave them three times the normal length of time to complete their apprenticeships.

According to Gorge, Institution Three was the first to start an online distance electrical apprenticeship program in the province. Gorge explained that the impetus for the program started in 2008 when the province's apprenticeship branch decided that it would offer competency-based apprenticeship training (CBAT) in the electrician program, the carpentry program, and the welding program. Gorge was involved with CBAT from the start, developing the curriculum and the modules. He noted that CBAT took into account students' individual learning styles, work histories, individual credentials, and the length of time of prior learning rather than the length of time they needed to be on-campus. Therefore, students did not need to complete the full on-campus term if they had attained all the knowledge and skills required. According to Gorge, CBAT evolved to ODL using an LMS based on the assessment portion of the TLM, which offered the ability to pick different exams.

Gorge was initially approached by industry refineries that had instrumentation technicians whom they wanted to have cross-trained into the electrician trade. This initial contact accelerated the design, development, and teaching of the ODL electrical apprenticeship program. The design of the apprenticeship program was a form of blended distance delivery and face-to-face laboratory classroom training, primarily created to meet the industry needs where the students could do most of the training remotely using the written modules and some online testing. Gorge explained that the electrician trade program at that time was classified as 90% theoretical and 10% practical. The online course was focused on the theoretical portion of the training and the students had to come to campus only to perform the hands-on experiments in the electrical laboratory. According to Gorge, Current, and Power, the online apprenticeship program was set up for students to read through their labs and draw the diagrams in preparation for on-campus laboratory activities. Gorge noted that after the blended program was established, Institution Three conducted a survey of the electrical apprentices to see if they wanted purely online courses. Few apprentices wanted everything to be available online. Gorge stated that the students wanted to be able to write on hard-copy modules that they could take with them into remote locations without Internet access. Recently, however, iPads and notebooks have become more prevalent and the online learning environment has become more widespread.

According to Power, the electrician ODL apprenticeship program was delivered in a blended learning environment and used the provincial ILMs. In contrast to the traditional on-campus, instructor-driven course in which the students work through modules, perform lab activities, and take tests as a group, the blended online distance course allowed students to work through the modules at their own pace. The interviewees explained that the program was a fixed-entry, open-exit course that students could complete early if they met all the objectives and passed the exams. After every module, the online students signed on and took a test. Students got three attempts to get 90% or better and then they moved on to the next module. Once the students had completed a number of modules, they took a supervised, on-campus, graded exam. Gorge, Current, and Power stated that TLM is the primary tool used for formative evaluations and for the module tests. Instructors were assigned to manage the exam question banks in the TLM. The computer support staff were available to help develop videos or animations.

In terms of interaction with software, Gorge and Current identified the LMS as the primary tool. The other tool was the on-campus laboratory called the computer-managed learning (CML) classroom, where the students worked on hands-on lab equipment, listened to traditional lectures, and received one-on-one tutoring. Current noted that the ODL apprenticeship program used animations and simulation activities to train the students with regard to the National Electrical Code. Gorge and Power explained that the instructors also used Visio for

PowerPoint presentations in the online learning environment and used Captivate to enhance the Visio. They also created other animations using other software such as Flash to enhance their online lectures using simulations.

For example the ODL apprenticeship program used a simulation for fire detection. Gorge said this fire alarm simulator won an award for its innovative approach to distance delivery. Current described the simulation as having been designed to demonstrate how a fire triggers a fire alarm. The student started a virtual fire in a building and the simulation showed how the fire developed and activated the components of the fire alarm system. Both Gorge and Current stated that the fire alarm simulator had been running online for years in the ODL and was used in part of the fire alarm and detection module of the course. According to Gorge and Current, both online and face-to-face electrical apprenticeship programs used this simulator. Due to its success, Institution Three planned to use more online animations.

Principle 1: Features Contributing to the Hierarchical Structure of Activities

Four key features contributed to the hierarchical structure of activities. They were: the functions of ODL technology, limitations of ODL technology, apprenticeship community conflict with ODL programs, and apprenticeship community influence on ODL programs.

Functions of ODL technology. According to Current, embedded video and simulations were not used at Institution Three because they were not initially available with the LMS systems and there were bandwidth issues. As well he explained that another reason that other add-on-based functions were not used was concern about the end-user. Current noted that those functions were limited to allow the "[end-] user to catch up with what the institution [is] using." Gorge stated that the TLM discussion board function had been disabled because students had highlighted an exam, copied it into the discussion, and sent it to the class. The software was designed purely for online use and not for the way Institution Three used it for only the examination portion (blended learning).

Gorge and Current agreed that the distance blended learning program module stipulated the same objectives for the online distance and the face-to-face students. Both online distance and face-to-face students had advisors. The only thing the online students did not have was access to the traditional lectures (i.e., their lectures were delivered in distance learning). Institution Three decided against the added-on components of Flash for animation, video, and social media. Students did not know other distance students unless they had a chance meeting in the lab. At the time of the study, the computational facilities did not support online exams for all 100 students, as there were only eight computers in the laboratory for student use.

Limitations of ODL technology. According to Gorge, the basic limitation to the use of technology in apprenticeship-based training was access to high-speed Internet. Gorge argued that limitations also included download speed which was affected by the number of wireless users in the Institution. Power stated that there might be up to 700 students trying to read a page wirelessly and the network system capacity could not handle it. He explained that the institution did not have the capability to allow the students to chat. Further, he stated that online class delivery was more expensive to deliver due to the cost of licences, network resources, extra design time, extra development time, and extra monitoring for class partition and learning.

According to Power, in a traditional face-to-face classroom, there might be up to 30 students in the class and one student answered or asked a question. The instructor asked a question or answered the student’s question and 30 students heard the answer right away. Power argued that unless there was a chat room that everybody was logged into and monitoring, all 30 students could ask the instructor the same question and the instructor might have to respond up to

30 times. Power also described limitations in online learning related to video delivery (synchronized delivery). The issues were the delivery of the video conference, the lag time, and the inability to write on the board. Instructors could not make notes as they could on the Whiteboard and assume that every student saw them, nor could they get cues from students' body language that tipped them off to flaws in their delivery.

Apprenticeship community conflict with ODL programs. Gorge noted that there were administrative conflicts between face-to-face learning objectives and online learning objectives in that the online format takes more time. Current described the conflicts between the face-to-face and the online learning objectives as being related to general educational procedures and expectations of students. Current stated that no matter what type of delivery the Institute was offering, there had to be a way to determine whether a student had learned the material that the instructor delivered: it could be journaling, a multiple choice test, or a project at the end of a course.

Gorge explained that Institution Three delivered TLM as text-based material for one of the primary sources of information. The students read a module and took a multiple choice test that was not counted toward their score. According to Current, the support for the module was one-on-one tutoring in a laboratory plus a hands-on lab to confirm theory learned online. For example when students performed an experiment demonstrating Ohm's Law, they could actually see the electrical formula in action and verify the simulation values. Current argued that the text-based material and lectures captured everything.

Current said that the issues of student motivation were independent of the type of delivery system. He noted that he often had to tell students in traditional classrooms that they had to complete modules to work their way through the program. He suggested that whether the student received instruction through a blended delivery or traditional face-to-face delivery, whether he or she was in jail or on an oil rig doing distance learning, the individual student still had to exert effort to learn the material. Current felt that there was not a superior model for delivery in this regard.

According to Gorge, there were no issues that might result in differences between face-to-face and online instructors as the Institution treated the instructors exactly the same. The only difference was that some of the online instructors agreed to work evenings. Watt argued that the collective agreement at the Institute stated that an instructor's hours of work are from 7:00 a.m. to 6:00 p.m., with no more than 7.25 hours in that day so if the instructor were teaching a distance online program or engaged in a synchronous activity in the evening, those activities were outside of the collective agreement and warranted a different funding model. Watt argued that, administratively, there was a conflict relating to measuring the number of students the Institution had in the online program. Distance students were not considered part of the Full Time Equivalent (FTE) count because those students had different start dates. Watt explained that in a face-to-face classroom, there was a fixed period like 10 or 12 weeks, but in a distance format or blended format, tracking who was working with the students was more difficult.

According to Gorge, Institution Three used Class Contact Periods (CCPs) and the instructors taught a fixed amount per year. If they exceeded that amount, they were paid for overload teaching. Gorge argued that the class size in the first and second year was restricted to 30 face-to-face students and the total number of CCPs for that class worked out to so many per student. That same amount was given to the instructor who worked online. The instructor was given four CCPs, the equivalent of four hours of teaching for one student, regardless of the amount of time the instructor spent in contact with the student.

According to Power, when the ODL electrical apprenticeship program first started, the number was as high as 200 students in the distance program and instructors were overloaded. Power argued that the fewer contact hours for each student had a negative effect on success and completion rates.

Apprenticeship community influence on ODL programs. According to Gorge, the apprenticeship community, including the instructors and industry employers, influenced the design and development of the online apprenticeship program. At the beginning, it was primarily the industry that influenced the design and development of the online apprenticeship program because it did not want to release employees to attend face-to-face classroom training. According to Gorge, employers wanted to keep their apprentices at their workplace so they often requested that an employee be admitted into the distance program and paid the tuition fee. In some cases, employers wanted a number of students to enter the program at the same time. Gorge argued that industry support was demonstrated when students said, “I want to make sure that I’m going to be finished by this date because my boss is giving me a $5,000 bonus if I’m finished by then.”

According to Gorge, the province also influenced the design and development of online apprenticeship programs at the early stages through providing access to video conferencing. The province provided access to courses that Institution Three was able to schedule in various communities. However, the quality and standards used for video conferencing were inconsistent throughout the province. Gorge explained that in one case a student was using a 19-inch monitor whereas other areas had 32-inch or larger monitors. Gorge also argued that as students became busier, working 12-hour shifts in their locations, the synchronous videoconferencing became problematic.

Principle 2: Social and Physical Aspects of the Online Learning Environment

Based on analysis of the interview data and documents, eight key aspects of the social and physical aspects of the online learning environment were identified. These included the characteristics of ODL apprenticeship programs, importance of ODL technology, integration of ODL technology, rules and regulations for ODL apprenticeship programs, and resources for ODL apprenticeship programs.

Characteristics of ODL apprenticeship programs. According to Current and Power, the characteristics of face-to-face and online training at Institution Three were basically the same. The main difference was in the delivery of the lectures. However, Institution Three was considering recording the lectures for both online distance and daytime students.

Current stated that the online technology environment was designed for face-to-face day program delivery with fixed entry, but delivered the online program in an open-exit, blended delivery format. Gorge and Current both noted that online students had an adviser but no face-to-face instruction on theory. The laboratory activities were much the same for both online and face-to-face students. Gorge mentioned that animations and interactive MS PowerPoint presentations had not been put online because Win Corp had discontinued support for it. Institution Three considered using Moodle, an open source and very powerful software; the limitation was that it did not provide testing features, which were the strength of TLM. The apprenticeship online learning activities were distributed asynchronously; students logged on whenever they wanted to take the assessment and accessed the modules available from the bookstore.

Importance of ODL technology. According to Gorge, the online environment had the potential to become an important part of the apprenticeship trade program because the student population was changing. For one thing, Gorge explained, students were increasingly computer-savvy and were “very comfortable with the technology.” In addition, Gorge stated that the students represented a wide age range, from 18-year-old high school graduates to 55-year-olds coming through the electrical apprenticeship program. In addition, they had a wide range of education.

According to Current, there was an industry policy to “allow as many people access to apprenticeship training as possible,” which included online distance learning. Current explained that this opened the door for students to attend technical schools as the industry wanted improved access to apprenticeship training. According to Current the industry was looking for the type of flexible apprenticeship training that could be delivered by the distance model. According to Gorge, there were many technologies available within the spectrum of online learning, including simulations that might help with flexibility of apprenticeship training. Both Gorge and Power noted that Institution Three purchased equipment to create simulations. These simulators also included drawing electronic circuits similar to computer-aided design (CAD), but with drag and drop (i.e., drag and drop a battery, light bulb, and a meter).

Current explained that the expanded access for distance learners had worked well for the online distance electrical apprenticeship program. Power noted that in 2012 online technology was an important part of apprenticeship trades training of 2,400 students, only 90 of whom were online. Without the online learning these students would likely not have considered the electrical apprenticeship trade as career. According to Current, the success was because the instructors had learners that had done their first and fourth years by distance and Institution Three provided access to those who would not have been able to attend full-time technical training.

Integration of ODL technology. According to Current, Institution Three had not integrated many activities in TLM because of the wide range in user hardware and the fact that TLM is being phased out. Current demonstrated the benefits of integrating activities; for example, in one of the modules an activity such as a simulation was used to demonstrate Ohm's Law. Students watched a lecture from an instructor who delivered the material and posted questions via a social media connection. Gorge had experience with embedding animations into materials so that when the student read about a parallel electrical circuit, there was an animation to demonstrate how it worked. Gorge explained that this approach was a type of digital storytelling.

Current said that Institution Three had not integrated many animation or simulations within the LMS for reasons which included cost and time to prepare. However, he saw opportunities to integrate simulations, including Lab Volt simulations from one of their lab equipment suppliers. The equipment used in the Lab Volt experiments looked exactly like what the instructors had in the lab. Power suggested that their fire alarm simulator, which was designed in WebCT and owned by Blackboard, be integrated into the online environment.

Rules and regulations for ODL apprenticeship programs. According to Current, the rules and procedures regulating social interaction and coordination in use of the online technology are quite flexible. Current explained that Institution Three initially followed the rules originally set out from the CBAT and the delivery method changed from CBAT paper-based to open-exit, blended, online learning. Current argued that the change occurred when the provincial government intervened and told Institution Three, "We're going to use Individualized Learning Modules (ILMs)," and staff was seconded from the Institute to create those ILMs. Once those were completed, all electrical apprenticeship institutions were required to use them.

Gorge explained that the provincial apprenticeship branch established administrative rules for who could apply to enter the online distance program. If students had not attended their online electrical apprenticeship for 18 months, they would be notified that their apprenticeship would be terminated. These rules improved the completion rates. Gorge reported that other criteria included when students took their last schooling and what score they attained on the apprenticeship exam. Both Gorge and Current noted that Institution Three arranged personal interviews with each student who was accepted into the distance program.

Resources for ODL apprenticeship programs. According to Power, there were few resources available to design and develop the online program in the late 1980s when the first pilot started. There was some minimal provincial funding when Institute Three converted the CBAT to TLM in 1998. Current explained that the provincial government had continued to use the Institutes to build the exams, but that it administered the exams in print form. The provincial government proctor brought the exams to the Institutes or field offices which was expensive and labor-intensive.

Principle 3: Components Contributing to Learning, Cognition, and Articulation of Online Activities

Through the data analysis, three components that contributed to the learning, cognition, and articulation of online activities were identified. These included learning in an ODL environment, learning access to ODL, and learning representation.

Learning in an ODL environment. According to Gorge, the amount of time and effort devoted to learning to use the online technology impacted the students' learning from both the students' and instructors' perspectives. Gorge explained that the concepts and vocabulary did not affect learning since the online apprenticeship training concepts and those of the face-to-face apprenticeship trades training were virtually the same. The students in both formats took the same exams. Power noted that the main difference was in the delivery of the educational material. If the student was struggling with the technology or even a concept with the technology, the instructor had to allow for that. Power explained that the TLM was very easy for students to use. Students who understood how to navigate a website and book a hotel online could easily use the online program.

Current explained that at Institution Three the time and effort required to learn to use the online technology was minimized through an orientation session. Following that, if students did not sign into the system, Current contacted them online individually to offer support. Online learning environment activities were designed to be user-friendly. According to Gorge, Institution Three found that the first-year apprenticeship students spent the most time learning the technology and apprenticeship ODL format. Gorge said that the challenge for first-year apprenticeship students was learning how to operate the software, how to retrieve the exams, and how to check their marks, but that in the second, third, and fourth years, these difficulties were reduced significantly.

Learning access to ODL. Current and Power both noted that ILMs were developed by the provincial government agency, which was a quasi-government organization. It oversaw their development, then the institution printed them, and students purchased them in the bookstore. All three instructors explained that the students printed the end-of-module tests and any other text-based materials (with the exception of supervised exams) and put them in binders for later reference. According to Current, the first-period lab package reflected a student’s typical learning experience. Students made drawings and answered a couple of questions. The typical lab environment and objectives were tied to the course. Within each of the modules, students learned about connecting electricity and there was a hazard assessment to ensure that students were aware of dangers in the lab.

Learning representation. All of the instructors noted that the online learning environment assisted in self-evaluations through instant feedback on the TLM. The exams consisted of multiple choice, fill-in-the-blank, matching, and true/false items; students had three attempts to score 90%. After the third try, they were locked out and had to contact their advisors. Typically the instructor signed on to see exactly how the student was having trouble. Gorge and Power explained that the test banks were designed so that when students made a second attempt, they would get different questions. If students went to a third attempt, chances were they might see a repeat. If they did not achieve 90% on the third attempt, they were blocked. The student had to go to an instructor and say, "Can you pass me to the second one?" This was an opportunity for the instructor to provide guidance. The instructor could also allow the student a fourth attempt.

According to Current, a fault in the system was that the students could pull the test, click "mark test," and get zero. The same student would do the same on the second test. This gave the student 50 questions to use in taking a third test. The instructor would warn the student, "You need to stop doing that. If you continue to do that, you might not get to stick around too long, because that's not the way that the system was designed."

Principle 4: Factors Contributing to the Development of the Online Activities

According to Power, the current instructors had experience or training with the online environment, but that at the time it was designed, no one had experience in developing online programs. Three key factors contributed to the development of the online apprenticeship trades training program at Institution Three. The contributing factors included implementation of ODL technology, apprenticeship community attitude toward ODL apprenticeship programs, and apprenticeship community barriers to ODL apprenticeship programs.

Implementation of ODL technology. Both Gorge and Current explained that Institution Three had developed courses that were delivered using the technologies that were available at the time. Current noted that the way that material was delivered was affected by the implementation of online technology. Twenty-five years ago, computers were used to manage CBAT testing. CBAT gave students access to the material and there was one-on-one tutoring. There was very little lecturing at the beginning. One of the reactions from industry and from the customer was, "You're using computers to teach." In fact, computers were used primarily to mark exams.

Current noted that Institution Three looked at computers and software differently. According to Current, "we're in a re-invention [phase] now with all the social media, and tablets, and the technology that is much more user-friendly and accessible." The Institution recognized that instructors needed to blend traditional delivery, labs, and one-on-one tutoring with online technology. According to Current, blended learning offered "the best of all worlds, and for us, the blend at some point will involve more technology."

Apprenticeship community attitude toward ODL apprenticeship programs. Gorge noted that the apprenticeship community's attitude toward the use of technology for learning was getting better. He stated that at the beginning of the development of the online program, electrical contractors were sceptical of the efficacy of the online program, but then the industry embraced it. Current noted that the apprenticeship community's attitudes toward online technology were mixed, but that some people were more receptive to online technology, particularly in a blended learning environment.

Institution Three's electrical apprenticeship online program had expanded and many instructors had not taught in any other format. The technology was a part of their lives, just as it was for their students. Instructors had become more efficient at using online technology and stakeholders knew how the system worked. Power noted that attitudes toward the use of technology in teaching and learning had become more positive because it gave access to students who would otherwise have difficulty attending school. Power noted that some students had said, "If I can't do it this way, I can't afford to come to school."

Principle 5: Components Contributing to the Zone of Proximal Development of Online Activities

Two components for enhancing student learning within the ZPD were identified through the data analysis. These were assessment in the ODL apprenticeship learning environment and scaffolding in the ODL apprenticeship learning environment.

Assessment in the ODL apprenticeship learning environment. According to Current, the ability to measure student retention and achievement levels through graded tests had played a role in the development of the online distance electrical apprenticeship program. Current argued that there were some challenges with this type of assessment, especially if there were calculus questions which could involve a page of work and often required an instructor to follow it through to see where the student had gone wrong.

Scaffolding in the ODL apprenticeship learning environment. According to Power, the scaffolding strategies used to enhance learning included the instructor setting the difficulty of each exam/quiz question. The difficulty levels followed Bloom's taxonomy levels. Gorge explained that the instructor could change the difficulty level and number of questions for each objective. For example, in the fire alarm simulator the student clicked on a link and simulated lighting a match and starting a fire. The simulator told the student a signal had been sent to the fire hall and a video came up with that. In addition, the simulator told the student that the temperature was rising. Power explained that the simulator ran through the whole fire alarm process from closing fire doors to alarms going off to sprinklers spraying water. The students' feedback was positive with this simulator activity because they could see the whole process. The simulator had assessment exercises that were marked only for competency. Power said that the simulator produced random questions so that every student got a different one. If the student got a question wrong, the program showed the correct answer and continued to mark the test.

Within the TLM, Power could see all the courses and monitor student progress. He could see whether his distance students had looked at the fire alarm module's questions, what a particular student was doing, and the number of attempts to pass the fire alarm quizzes. He could go into TLM and see what the students saw when they pulled up a module.

Summary

This individual case analysis of the three institutions examined the affordances and constraints of online learning technologies used by instructors in distance learning environments within the context of electrical apprenticeship trades education programs. In analyzing the design, development, and teaching experiences of the participants, themes emerged that were associated with the five activity theory principles. The themes were further examined and analyzed in Chapter Five through cross-case analysis that identified the commonalities and differences among the three cases.

Chapter Five: Cross Case Analysis

In Chapter Five an analysis of three cases and six participant interviews using the five activity theory principles as a theoretical lens was identified the commonalities and differences across cases. The five principles of activity theory were: hierarchical structure of activities; social and physical aspects of the environment; learning, cognition, and articulation of activities; development; and zone of proximal development.

Principle 1: Hierarchical Structure of Activities

Activity theory differentiated between processes at various levels within an activity system; this differentiation took into consideration the objects to which these processes were oriented (Kaptelinin & Nardi, 2006). The hierarchical structure of activities determined the extent to which online technologies used in online apprenticeship trades enabled or constrained and provoked or resolved conflicts between different levels of apprenticeship program goals. Activity was driven by a motive; the middle level was driven by a goal; and the bottom level was driven by the conditions and tools. This multiple case study identified commonalities and differences contributing to the hierarchical structure of activities. Table 5-1 is an overview that summarized the data for each institution’s delivery of its ODL electrical apprenticeship program.

Table 5-1

Cases Overview Comparison

	Case Study One		**Case Study Two**		**Case Study Three**	
	Online Model		**Blended Model**		**Blended Model**	
	Theory	**Practical (hands on)**	**Theory**	**Practical (hands on)**	**Theory**	**Practical (hands on)**
Type of Delivery	Online distance learning	Employer (no classroom or laboratory)	Online distance learning	In-class experiments/laboratory	Online distance learning	In-class experiments/ laboratory
Maximum Students	No limit	No limit	Cohort group of 16 students per instructor	Cohort group of 16 students per instructor	No limit. 20 students is the benchmark	12 students per instructor
LMS	TLM, Blackboard Collaborate (Elluminate *Live!*)	--	D2L as the LMS TLM as exam drills and practice exams.	--	TLM	--
Number of Weeks	3 months for each 30 hour course. Self-paced (open entry and exit). 12-30 hour courses each	No formal practical training (must be completed before writing the IP exam) as the training was done by employer and signed off	3rd year period had a total of 16 weeks (both theory and practical) 12 weeks allotted for the online theory 4th year period had a total 21 weeks (both theory and practical) 16 weeks allotted for the theory	3rd year period -4 weeks campus lab component. 4th year is a 5 weeks campus lab component.	3rd year period – 24 weeks, 4th year period – 36 weeks	3rd year period – 8 weeks, 4th year period – 12 weeks
Competencies Assessment	Minimum 70% on provincial final exam after each course completed	Completion of assignments in log book (signed and witnessed by the employer)	Minimum 70% on provincial final exam after each year completed	Electrician trade the practical hands-on skills were taught on the jobsite Campus labs supported the theory (signed and witnessed by the instructor)	Minimum 70% on provincial final exam after each year completed	Observation of experiments (signed and witnessed by the instructor)

ODL technology limitations. Aspects of ODL technologies that enabled or constrained apprenticeship program goals that were shared among all instructors included the limited use of videos, animations, and simulations. From the interviews with participants, Institution Two instructors felt that using animation would be beneficial if they could use it on the students' smartphones. However, all six of the instructors noted that the use of videos, animations, and simulations in apprenticeship-based training was limited due to their file sizes and bandwidth, all of which required a reliable Internet connection. At Institution Three, instructors noted that not all students had access to high-speed Internet which posed a problem for using the online simulator.

Other common issues identified by the instructors included those related to the delivery of the video conferences, such as the lag time, the inability to write on the board, and the inability to get cues from students' body language. Although Institution Two instructors encouraged working with other peers even though there were no formal group activities within the online apprenticeship training curriculum, neither Institution Two nor Institution Three instructors used the collaboration functions of discussion boards in the LMS because students took advantage of the chat function to distribute copies of exams to the class. However, Institution One instructors used collaboration for web tours, application sharing, and, if the session were synchronous, the chat feature.

Apprenticeship program delivery conflict. The primary conflict between the face-to-face and online apprenticeship program delivery identified at Institution Two was the instructors shift from a structured class timetable to a flexible schedule based on an open classroom. Institution Three instructors shared similar experiences as the Institution's upper management treated the face-to-face and online instructors in exactly the same way with regard to hours. The only difference was that some of the online instructors agreed to work evenings. In both Institutions Two and Three all instructors argued that the face-to-face and online instructors' hours of work violated the collective agreement. Constraints occurred when the instructor taught a distance online program or engaged in a synchronous activity in the evening; those activities would be outside of the collective agreement. At Institution Three, administrators regulated the number of online students that each instructor could teach per year. If the instructors exceeded that amount, they were paid for overload teaching. At Institution Two, both ODL instructors taught the course from continuing studies as was dictated by the funding model. In addition to the apprenticeship program delivery conflict of ODL technology, the lack of support of the employer and a non-user-friendly LMS contributed to the delivery conflict of ODL electrical apprenticeship programs at Institution Two.

Apprenticeship community attitude. At Institutions One and Three, it was reported by all four instructors that other face-to-face instructors were indifferent to or unaware of what happened in the online learning courses. An example of this was the development of the delivery of ODL activities. As soon as the face-to-face instructors saw the value in those activities, they included them as part of the in-class curriculum. At Institutions One and Two, it was noted by all three instructors that some face-to-face instructors gave the online instructors a hard time; for example the face-to-face instructors made disrespectful comments about how easy it was to be an online instructor compared to being a face-to-face instructor.

Apprenticeship community influence. At Institution Two, both instructors reported that the industry's influence on the design and development of the online apprenticeship program was somewhat negative as evidenced through their questioning whether the ODL apprenticeship curriculum content was the same as the face-to-face apprenticeship curriculum. In contrast, the apprenticeship community, including the instructors and industry employers, positively influenced the design and development of the online apprenticeship program at Institution Three. Both Institutions Two and Three instructors shared similar experiences with the province's influence on the design and development of online apprenticeship programs through providing additional funding to initiate the ODL design and development and also through promoting the online option on the provincial government website.

Table 5-2 is an overview of the key findings from six participant interviews in three case studies using the activity theory principle hierarchical structure of activities as a theoretical lens to identify the commonalities and differences across the three cases.

Table 5-2

Summary of Activity Theory Principle 1: Hierarchical Structure of Activities Key Findings

<table>
<tr><th rowspan="2">Themes</th><th>Case Study One</th><th>Case Study Two</th><th>Case Study Three</th></tr>
<tr><th>Online Model</th><th>Blended Model</th><th>Blended Model</th></tr>
<tr><td rowspan="3">ODL Technology Limitations</td><td rowspan="2">- video has lag time
- unable to write on the board and obtain cues from students' body language
- collaboration used for Web tours, application sharing, and chat</td><td>- animation possible on students' smartphones
- work with peers is encouraged</td><td>- Some students lack high-speed Internet; interfered with use of the online simulator</td></tr>
<tr><td colspan="2">- did not use the collaboration functions of discussion boards in the LMS
- students use chat to distribute copies of exams to the class</td></tr>
<tr><td colspan="3">- use of videos, animation, and simulation in apprenticeship-based training was limited by file sizes and bandwidth</td></tr>
<tr><td rowspan="2">Apprenticeship program delivery conflict</td><td rowspan="2"></td><td>- shift from a structured to flexible class timetable
- course taught from continuing studies according to the funding model
- lack of support of the employer and a non-user-friendly LMS contributed to delivery conflict</td><td>- institution's upper management treated face-to-face and online instructors in the same way regarding hours
- administrators regulated the number of online students each instructor could teach per year</td></tr>
<tr><td colspan="2">- face-to-face and online instructors' work hours violated the collective agreement</td></tr>
<tr><td rowspan="3">Apprenticeship community attitude</td><td rowspan="2">- face-to-face instructors were indifferent to or unaware of what happened in the online learning course</td><td colspan="2">- province's influence on the design and development of online apprenticeship programs through funding to initiate the ODL</td></tr>
<tr><td>- the industry's influence on the design
- development of the online apprenticeship program was initially negative</td><td rowspan="2">- face-to-face instructors were indifferent to or unaware of what happened in the online learning courses
- instructors and industry employers positively influenced the design and development of the ODL program</td></tr>
<tr><td colspan="2">- face-to-face instructors hassled the online instructors</td></tr>
</table>

Principle 2: Social and Physical Aspects of the Environment

The principle of the social and physical aspects of the environment referred to the integration of online technologies with the environment's requirements, tools, resources, and social and cultural rules so as to transform objects in the online learning environment (Kaptelinin & Nardi, 2006). The principle identified the activity theory approach as applied to the environment with which individuals are interacting. According to Kaptelinin and Nardi (2006), the cognitive approach for making sense of a problem was the individual mental process for making connections between learning and the real world.

This multiple case study identified commonalities and differences contributing to the social and physical aspects of the environment. At all three institutions, the instructors agreed that concepts and vocabulary of online apprenticeship electrical trades training were relatively consistent with those of face-to-face apprenticeship electrical trades training. The only difference was in terminology specific to the software, such as Blackboard compared to TLM relating reading individual threads and accessing folders.

ODL importance. Instructors from all three institutions noted that online technology was an important part of electrical apprenticeship trades training as it supported the industry by minimizing work disruptions. Online technology was critical to Institution Three's instructors' ability to accommodate the different types of learners. The importance of online technology for apprenticeship was reflected by continued industry and institute support for Institution Two's electrical apprenticeship program. Furthermore, industry support at Institution Three opened the door for students to attend technical schools as the industry wanted improved access to apprenticeship training. One of the Institution Three instructors explained that employers encouraged employees to attend the ODL electrical apprenticeship program by providing salary bonuses if they completed their training early.

Technology integration. Institution One used TLM and Blackboard with Elluminate *Live!* and occasionally integrated simulations, animation, and other online web resources with their learning management system. Institution Two instructors used TLM and D2L learning management systems which were capable of integrating simulations and videoconferences. Other tools and technology such as the Institution Two Mediator software was also used. Both Institutions Two and Three agreed that TLM was most useful for test banks for the module assessments. Institution Three had not integrated many activities in TLM because of the wide range of user hardware and the fact that the institution was replacing TLM with another LMS.

At Institution One, Blackboard and MS PowerPoint had been found to work well for integration, for example, importing MS PowerPoint presentations and then saving them as files within Elluminate *Live*. MS Word and PDF documents also worked well for integration.

Characteristics of ODL apprenticeship training. The characteristics of apprenticeship trades training in face-to-face classrooms were consistent with those in online environments at all three institutions. Institution One instructors occasionally delivered ODL synchronously, while instructors at Institution Three recorded the lectures for both online distance and daytime students. Both Institutions One and Two used activities initially designed for the online environment in the face-to-face courses; neither reported differences between face-to-face and online learning objectives.

Institution One's all-online program had no face-to-face, hands-on portions in the classroom laboratory. In both Institutions Two and Three the blended learning model had fewer students working in the laboratory compared to the face-to-face program. In Institution One's all-online program, the student's practical hands-on training was provided by the employer (i.e., electrical master journeyman). The ODL environment taught by instructors at Institutions Two and Three was designed for face-to-face day program delivery with fixed entry, but was delivered online in an open-exit, blended delivery format. Institutions Two and Three provided online students with advisors for the hands-on laboratory.

Rules and regulations. Institution One's provincial government provided the curriculum for the electrical apprenticeship trades and set the time frame for each outcome. The province allowed Institution One instructors to determine how the curriculum would be delivered and did not dictate what activities were to be used to teach the curriculum. Institution One's provincial government did not restrict who could enter the online distance apprenticeship program, yet for both Institution Two and Three, the provincial apprenticeship branch devised rules about entrance to the online distance program.

Institution Two administrators set their own rules and procedures regulating social interaction and coordination related to the use of the online technology. These rules were communicated during the student orientation session. Institution One had its own rules and procedures regulating social interaction and coordination related to the use of the online technology, but did not require that students attend an orientation session. Institution Three's rules and procedures regulating social interaction and coordination related to the use of the online technology were quite flexible for the instructors. However, Institution Three instructors initially followed the rules originally set out from the CBAT until the provincial government intervened and told them to use the provincially administered Individualized Learning Modules (ILMs).

Resources. The development of all three institutions' online learning programs was initially funded by the provincial governments. Institution Three instructors had other resources, including the learning community and the industry (i.e., large corporations, manufacturing plants, and oil companies) that provided financial support.

Table 5-3 provides an overview that summarized the key findings from six participant interviews in three case studies using the activity theory principle *Social and Physical Aspects of* *the Environment* as a theoretical lens by which to identify the commonalities and differences across the three cases.

Table 5-3

Summary of Activity Theory Principle 2: Social and Physical Aspects of the Environment Key Findings

<table>
<tr><th rowspan="2">Themes</th><th>Case Study One</th><th>Case Study Two</th><th>Case Study Three</th></tr>
<tr><th>Online Model</th><th>Blended Model</th><th>Blended Model</th></tr>
<tr><td rowspan="2">ODL Importance</td><td></td><td></td><td>- provided ability to accommodate the different types of learners
- opened the door for students to attend technical schools
- employers given salary bonuses if students completed their training early by ODL</td></tr>
<tr><td colspan="3">- online technology supported the industry by minimizing work disruptions</td></tr>
<tr><td rowspan="2">Technology Integration</td><td rowspan="2">- occasionally integrated simulations, animation, and other online Web resources with LMS
- Blackboard and MS PowerPoint were effective for integration</td><td>- capable of integrating simulations and videoconferences</td><td>- poorly integrated and the institution replaced LMS</td></tr>
<tr><td colspan="2">- TLM was most useful for test banks for the module assessments</td></tr>
<tr><td rowspan="2">Characteristics of ODL Apprenticeship Training</td><td>- occasionally delivered ODL synchronously
- ODL program had no face-to-face, hands-on portions in the classroom laboratory
- ODL program and the student’s practical hands-on training was provided by the employer</td><td colspan="2">- blended learning model enabled fewer students to work in the laboratory than the face-to-face program
- designed for face-to-face day program delivery with fixed entry, but was delivered online in an open-exit, blended delivery format
- provided online students with advisors for the hands-on laboratory</td></tr>
<tr><td colspan="2">- used activities initially designed for the online environment in the face-to-face courses
- no differences between face-to-face and online learning objectives</td><td>- recorded the lectures for both online distance and daytime students</td></tr>
<tr><td rowspan="2">Rules and Regulations</td><td rowspan="2">- provincial government provided the curriculum and set the time frame for each outcome
- province allowed instructors to determine how curriculum would be delivered and taught
- provincial government did not restrict who could</td><td>- administrators set their own rules and procedures regulating social interaction and coordination related to the use of the online technology</td><td>- use of online technology was quite flexible for the instructor
- instructors initially followed the rules established by the CBAT</td></tr>
<tr><td colspan="2">- provincial apprenticeship branch devised rules for entrance to the</td></tr>
</table>

Themes	Case Study One Online Model	Case Study Two Blended Model	Case Study Three Blended Model
	enter the ODL program - Institution had its own rules and procedures regulating social interaction and coordination related to the ODL technology - no requirement for students to attend an orientation session	online distance program	
Resources			- instructors had other resources, including the learning community which provided financial support

Principle 3: Learning, Cognition, and Articulation

The principle of learning, cognition, and articulation included the mental and external components of activities that facilitated problem solving (Kaptelinin & Nardi, 2006). This multiple case study identified commonalities and differences which contributed to learning, cognition, and articulation of activities.

Learning. All instructors from the three institutions agreed that there were very few differences between face-to-face and online learning objectives that might lead to conflict in learning. The programs' objectives or outcomes were incorporated in the base outline and approved by the provinces so they were basically the same. However, the amount of time and effort devoted to learning to use the online technology impacted the students' learning. The instructor from Institution One noted that younger students who had grown up in the computer age were more computer proficient than some of the older students. After the students became familiar with the technology, they were able to navigate the online learning environment and participate in online activities. Institution Two instructors noted that the student orientation on using LMS minimized the amount of time and effort in learning to use the online technology.

Both Institutions Two and Three instructors agreed that multimedia activities often required some extra effort to learn how to manipulate things in the online learning environment. Institution Three instructors found that students who completed their first year apprenticeship program online were much more skilled in operating the software than were those who started the online program in their second, third, or fourth years. The time required to learn how to use the technology was reduced significantly.

Access. Institution One's course materials were accessible online and could be ordered online by the students. Institutions Two's and Three's course materials were available from the provincial government agency or at the Institution which could print the materials and distribute them through the bookstore.

Representation. All three institutions' instructors agreed that the online learning environment helped in self-evaluations through the use of end-of-module review tests and guided corrective feedback. The exams were designed to have different questions for subsequent attempts. The evaluations allowed students to assess their comprehension and gage their preparation to write their graded final exam.

Pilot. From the interview data, all six instructors participated in some form of pilot testing of the online distance apprenticeship training activities. Instructors from Institution One participated in a pilot test that was on the industrial electrician's online program. At Institution Two, instructors participated in pilot tests of the online distance apprenticeship training activities which included a year's worth of pilots with three classes of fourth-year electrical apprentices; the pilot process provided a better understanding of what an online environment was like. Institution Three's instructors participated in a pilot started with the CBAT program which evolved into the online distance apprenticeship program. Institution Three instructors conducted further pilot tests of the online media items.

Table 5-4 provides an overview that summarized the key findings from six participant interviews in three cases using the activity theory principle *Learning, Cognition, and Articulation* as a theoretical lens to identify the commonalities and differences across the three cases.

Table 5-4

Summary of Activity Theory Principle 3: Learning, Cognition, and Articulation Key Findings

<table>
<tr><th rowspan="2">Themes</th><th>Case Study One</th><th>Case Study Two</th><th>Case Study Three</th></tr>
<tr><th>Online Model</th><th>Blended Model</th><th>Blended Model</th></tr>
<tr><td rowspan="3">Learning</td><td rowspan="2">- younger students who grew up in digital age were more computer proficient than older students
- students became familiar with the technology and were able to navigate the ODL environment</td><td>- student orientation with LMS minimized amount of time and effort in learning to use the online technology</td><td>- students who completed their first-year apprenticeship program online were more skilled than those who started it in their second, third, or fourth years</td></tr>
<tr><td colspan="2">- often required extra effort to learn how to manipulate things in the ODL environment</td></tr>
<tr><td colspan="3">- very few differences between face-to-face and online learning objectives that might lead to learning conflicts</td></tr>
<tr><td>Access</td><td>- materials were accessible/could be ordered online</td><td colspan="2">- course materials were available from the provincial government agency or at the institution bookstore</td></tr>
<tr><td>Representation</td><td></td><td></td><td>- ODL environment helped in self-evaluations through the use of end-of-module review tests</td></tr>
<tr><td>Pilot</td><td>- pilot test was on the industrial electrician’s online program</td><td>- instructors participated in ODL apprenticeship training activities that included a year’s worth of pilots with three classes of fourth-year electrical apprentices; the pilot process provided an understanding of an online environment</td><td>- instructors participated in a pilot started with the CBAT program; evolved into the online distance apprenticeship program
- conducted further pilot tests of the online media items</td></tr>
</table>

Principle 4: Development

According to activity theory, knowing how a phenomenon developed into its existing form lead to understanding it (Kaptelinin & Nardi, 2006). This multiple case study identified commonalities and differences contributing to development of online distance learning apprenticeship trade programs.

Implementation. From the interview data it was found that both Institutions One and Two instructors shared common effect that the implementation of online technology for the apprenticeship trades program was minimal. However, Institution One instructors noted that implementing the online program resulted in some very negative feelings among the non-online instructors who felt threatened. However, after the ODL program was instituted, the number of instructors increased. Institution Two instructors felt that the ODL program had not greatly changed the electrical apprenticeship because it was just in its second year. However, the implementation process included some heated discussions among the three instructors with some background in design and the instructional design SMEs who refused to listen to the instructors. The three instructors put together the ODL program and combined their resources in terms of the teaching structure and the learning.

Institution Three instructors delivered its courses using the technologies that were available when the CBAT program was developed. Institution Three instructors were looking for ways to take advantage of more current technology and computers.

Apprenticeship community. At the beginning of the electrical ODL apprenticeship program development, Institutions One, Two, and Three instructors experienced some form of negative attitudes from the apprenticeship community (i.e., face-to-face instructors, employers, industry, and electricians). From the interview data, it was reported that initially the community was sceptical about the quality of the ODL apprenticeship program. After the program had been in operation for a short time, the community became more receptive to the online technology, particularly to a blended learning environment. As a result, instructors in all three institutions received support from the apprenticeship community. Furthermore, when the community became aware of the demand for flexible apprenticeship training, was assured that the quality of the program was not compromised, and realized that the training could help with the electrical apprenticeship trade shortages, its support increased.

On occasion it was reported by Institution Two ODL instructors that they sometimes felt that the quality of the apprentices taught by ODL was still questioned, perhaps because of a lack of understanding about how the ODL was delivered. At Institution Three, instructors became more proficient at using online technology and some in the industry came to know how the system worked. Institution Two instructors noted that the online instructors and students felt they were part of the school community and were treated fairly with their counterparts in the face-to-face electrical apprenticeship program.

In addition, the community also included administrations, unions, and employers that represented the instructors. At Institutions Two and Three the collective agreement stipulated the number of contact hours per year. Working on evenings and weekends which was often expected of ODL instructors was not condoned by the collective agreement.

Table 5-5 provides an overview that summarized the key findings from six participant interviews in three cases using the activity theory principle *Development* as a theoretical lens to identify the commonalities and differences across the three cases.

Table 5-5

Summary of Activity Theory Principle 4: Development Key Findings

<table>
<tr><th rowspan="2">Themes</th><th>Case Study One</th><th>Case Study Two</th><th>Case Study Three</th></tr>
<tr><th>Online Model</th><th>Blended Model</th><th>Blended Model</th></tr>
<tr><td rowspan="2">Implementation</td><td>- implementation initially resulted in negative feelings</td><td>- ODL program had not greatly changed the electrical apprenticeship</td><td rowspan="2">- delivered its courses using the technologies that were available when the CBAT was developed
- look for ways to take advantage of more current technology and computers</td></tr>
<tr><td colspan="2">- the implementation of online technology for the apprenticeship trades program was minimal</td></tr>
<tr><td rowspan="3">Apprenticeship Community</td><td rowspan="2">- Initially experienced some form of negative attitudes from the apprenticeship community</td><td>- quality of the apprentices taught by ODL was still questioned
- the online instructors and students felt they were part of the school community and were treated fairly</td><td>- industry interested in learning how the system worked</td></tr>
<tr><td colspan="2">- collective agreement stipulated number of contact hours per year
- initially experienced some form of negative attitude from apprenticeship community
- after implementation, received support from apprenticeship community (i.e. industry)</td></tr>
<tr><td colspan="3">- community became aware of demand for flexible apprenticeship training and was assured that the quality of the program was not compromised; its support increased</td></tr>
</table>

Principle 5: Zone of Proximal Development

The zone of proximal development (ZPD) was what students could achieve on their own compared to what they could achieve through instruction (Kaptelinin & Nandi, 2006). This multiple case study identified commonalities and differences contributing to the ZPD for online distance learning apprenticeship trade programs.

Assessments. According to an Institution One instructor, exams were developed by the provincial apprenticeship board using multiple choice final exam questions. Institution One exams were set up this way to ensure objective marking. Exam limitations included the type of exams, project presentations, written papers, and the ability to test verbally. At Institution Two, assessments were performed to determine progress toward course objectives and to measure the ability of the student to tackle more complex problems. Students in the fourth year, whether in the online or the face-to-face program, were expected to have developed certain abilities and to have reached certain skill levels.

With all six instructors, the ODL electrical apprenticeship program included formative evaluations at every stage (mainly after each module) to prepare the student for the final Trade Qualification (TQ) exam and the Inter Provincial (IP) final exams. Institution Three instructors had challenges with this type of assessment when there were calculus questions, but Institutions One and Two instructors were able to overcome those challenges.

Scaffolding. It was reported through interviews at Institution One that scaffolding strategies which were used to enhance learning included giving the students the material and asking them to read it and to complete the study questions. Institutions Two and Three instructors applied scaffolding strategies to enhance learning including having the instructor set the difficulty of each exam/quiz question by following Bloom's Taxonomy levels. Using Bloom's Taxonomy, for a question that was Level 1 – Understand, students needed to recall a formula used for electrical circuits. For a question that was for Level 3 – Apply, students needed to apply their skills to solve a problem such as sizing an electrical service connection. For a question that was Level 5 – Create, students needed to build relationships to apply to new situations such as what would happen if the 120 volt black wire were grounded?

Table 5-6 provides an overview that summarized the key findings from six participant interviews in three cases using the activity theory principle z*one of proximal development* as a theoretical lens to identify the commonalities and differences across the three cases.

Table 5-6

Summary of Activity Theory Principle 5: Zone of Proximal Development Key Findings

<table>
<tr><th rowspan="2">Themes</th><th>Case Study One</th><th>Case Study Two</th><th>Case Study Three</th></tr>
<tr><th>Online Model</th><th>Blended Model</th><th>Blended Model</th></tr>
<tr><td rowspan="2">Assessments</td><td>- exams were developed by the provincial apprenticeship board using multiple-choice final exam questions
- Exam limitations included the type of exams, project presentations, written papers</td><td>- assessments were performed to determine progress toward course objectives and measure students' ability to tackle more complex problems
- fourth-year students in the online or face-to-face program were expected to have developed certain skill level</td><td>- challenges arose with this type of assessment when there were calculus questions</td></tr>
<tr><td colspan="3">- ODL electrical apprenticeship program included formative evaluations at every stage to prepare students for the TQ and IP final exams</td></tr>
<tr><td>Scaffolding</td><td colspan="3">- scaffolding strategies to enhance learning consisted of giving material to students and asking them to read it and complete study questions</td></tr>
</table>

Summary

This cross-case analysis identified the commonalities and differences related to online learning technologies used by instructors in distance learning environments within the context of electrical apprenticeship trades education programs at the three institutions. What became evident from this examination was that all of the institutions reported that using animations would be beneficial if instructors could use them on the students' smartphones. All of the instructors also agreed that the use of videos, animations, and simulations in apprenticeship-based training was limited due to their file sizes and bandwidth which required a reliable Internet connection and all noted that the inability to write on the board was problematical. A key difference was that the use of synchronous collaboration was not consistent between all cases. One instructor used collaboration for web tours and application sharing but the other five instructors rarely used it. Another difference was that one institution required mandatory student orientation for ODL students whereas the others did not. Finally, the most significant difference was that the requirement for in-class laboratory experiments was not required for all cases, whereas two cases required face-to-face, in-class laboratory experiments. In Chapter Six, there is a discussion of the findings and implications identified in a number of sources of affordances that affect the design, delivery, and teaching of online apprenticeship trades programs.

Chapter Six: Discussion and Implications

In Chapter Six the results were discussed in terms of the extent to which instructors encountered affordances and barriers when designing, delivering, and teaching online apprenticeship trades programs. The five principles of activity theory were used to search for tension and contradictions between subjects (instructors) and objects (learning tasks) (Engeström, 1999; Nardi, 1996). The five principles of activity theory applied to this research were (a) the hierarchical structure of activities; (b) the social and physical aspects of the environment; (c) learning, cognition, and articulation of activities; (d) development; and (d) the zone of proximal development (ZPD).

The focus of this research was on discovering the affordances and constraints of online learning technologies used by instructors in online distance learning environments within the context of electrical apprenticeship trades education programs. The following research question guided the current inquiry: How did the affordances of online distance learning (ODL) technologies enable or constrain instructors who were teaching in an apprenticeship trade ODL program? The following sub-questions were used to investigate the topic further:

1. How might the affordances and constraints affect the design and development of online distance apprenticeship trades training programs?
2. In what kinds of social and physical environments did online technologies integrate with environmental requirements, tools, resources, and social and cultural rules?
3. How might online distance apprenticeship trades programs affect training competencies and could these competencies be addressed in specific training activities?
4. How might the effect of implementation of online distance apprenticeship trades

programs influence the design of future apprenticeship trades programs?

5. How might the development of online distance apprenticeship trades programs affect the instructors' abilities to measure student assessment and achievement levels?

Effect of ODL Technologies on ODL Design of Apprenticeship Trades Programs

The research sub question "how might the affordances and constraints affect the design and development of online distance apprenticeship trades training programs" examined the hierarchical structure of the activities and determined the extent to which "the technology facilitates and constrains attaining users' goals and [the] impact of the technology on provoking or resolving conflicts between different goals" (Kaptelinin & Nardi, 2006, p. 270). It was apparent from interviewing all six instructors that the effect of online distance learning (ODL) technologies could best be defined in terms of how people used them and how the community influenced them (Kaptelinin & Nardi, 2006), focusing both on (a) technology's limitations and possibilities and (b) the apprenticeship community's attitudes and influence.

ODL technology limitations and possibilities. After the design and development of the ODL apprenticeship program was completed, it was evident from all six instructors that there was a pilot process with a small sample of apprentices before the program was opened to a larger population. From the interview data, it became evident that all six instructors had participated in some form of pilot testing of the online distance apprenticeship training activities. One instructor had participated in a pilot test that was on the industrial electrician's online program. Three instructors had participated in pilot tests of the online distance apprenticeship training activities which included a year-long series of pilots with three classes of fourth-year electrical apprentices. The pilot process provided a better understanding of what an online environment was like. According to the Canadian Apprenticeship Forum, Forum canadien sur l'apprentissage

[CAF-FCA] (2013), “the adoption of new technology has accelerated in recent years” (p. 8) as was apparent from one instructor whose experience exemplified that previous forms of distance delivery of apprenticeship programs such as competency-based apprenticeship training (CBAT) had evolved into the online distance apprenticeship program.

According to the instructors who participated in the study the results of the ODL electrical program pilot studies highlighted some limitations of the ODL technologies that constrained program activities. For example, not all students, institutions, or instructors had access to high-speed Internet. Instructors reported that the lack of a reliable Internet connection constrained the use of videos, animations, and simulations due to their file sizes and bandwidth. Further, lack of high-speed Internet constrained access to an interactive learning environment tailored to learners’ needs via a software application that “automate[d] the administration, tracking, and reporting of training events” (Ellis, 2009, p. 1). Other problems that the instructors associated with ODL environments were the lag time experienced by users with slow Internet connections, the inability to write on the online discussions board, and the inability to get cues from students’ body language, all of which had an impact on teaching effectiveness. Another constraint was the need to disable the chat function to prevent students from distributing copies of completed exams to the class.

According to CAF-FCA (2013), “both on-the-job training and technical training will demand a higher level of computer literacy than in the past as apprentices will be asked to find codes and regulations online and use smartphones, apps, and tablets” (p. 5). It was evident from the instructors that the affordances of ODL technologies included encouraging student collaboration and allowing application sharing by means of online discussion boards. ODL technologies were useful for setting up synchronous sessions. They also enabled instructors to use videos, animations, and simulations that could operate on smaller devices such as the students' smartphones.

The ODL apprenticeship program delivery may have constrained the instructor's ability to shift from a structured class timetable to a flexible schedule based on an open classroom. The online instructors' hours of work at some institutions violated collective agreements. Lack of a user-friendly LMS contributed to issues regarding the delivery of ODL electrical apprenticeship programs.

Apprenticeship community attitude and influence. It was apparent from all of the instructors that the apprenticeship community's attitude about the use of online technology in the learning environment was initially negative. Nike from Institution One reported that"one of the guys said, 'you can't teach electricians on a TV set'." Amp from Institution Two described "the apprenticeship community's influence on the design development of the online apprenticeship program, in terms of employers, in terms of, again, the mindset, initially was very sceptical. Now when they see the results of what was developed, they're very supportive." Power from Institution Three noted that "there's a much better understanding from industry about what can be done in a classroom now versus a traditional view of what should be done in a classroom. So people are more receptive to technology." According to CAF-FCA (2013), the apprenticeship community felt that "various technologies do not, however, replace real experience on the job site or the value of instructor-supported learning" (p.14). Therefore, the community had "mixed views on whether online learning is more suitable for advanced level courses or [is] equally suitable for all levels" (p. 22). However, the instructors noted that after the programs were in full operation, the face-to-face instructors came to see ODL apprenticeship training as an asset. Overall the apprenticeship community, including the instructors, industry employers, and the provincial government, has positively influenced the design and development of the use of online technology for the apprenticeship program through providing resources and marketing.

Furthermore, the research data from the instructors confirmed that the apprenticeship community including the instructors and industry employers positively influenced the design and development of the online apprenticeship program since the "skilled trades workplaces are becoming increasingly reliant on technology, with new equipment and systems that require a greater degree of flexibility and enhanced digital skills" (CAF-FCA, 2013, p. 2). Five of the six instructors in the study agreed that their provinces had influenced the design and development of online apprenticeship programs through providing additional funding to initiate the ODL design and development.

Integration of Online Technologies with the Environment

The research sub question "in what kinds of social and physical environments do online technologies integrate with environmental requirements, tools, resources, and social and cultural rules?" investigates the integration "of [the] target technology with requirements, tools, resources, and social rules of the [learning] environment" (Kaptelinin & Nardi, 2006, p. 270) to perform tasks. Kaptelinin and Nardi described an environment as the "objects involved in target activities" (p. 271) when using the "target technology" (p. 271). The results that motivated and directed activities were the objects of activities. The research data identified five items related to the integration of online technologies with the environment: ODL importance, technology integration, characteristics of ODL apprenticeship training, rules and regulations, and resources.

ODL importance. It was reported by all six instructors that online technology was an ongoing important part of electrical apprenticeship trades training as it supported the industry by minimizing work disruptions and by accommodating different types of learners. According to

CAF-FCA (2013), the industry was very supportive of online training in the apprenticeship trades as it "eliminate[d] the disruption to their operations when an apprentice [left] the workplace to attend technical training" (p. 23). It was also evident from the instructors that employers provided incentives such as promotions and higher pay for employees to attend the ODL electrical apprenticeship program and by providing them with salary bonuses if they completed their training early.

Technology integration. The interviewees described ways in which the integration of ODL technologies had a significant impact on the environment; for example, software programs such as The Learning Manager (TLM) and Blackboard with Elluminate *Live*! were capable of integrating simulations and videoconferences. Some institutions have integrated these capabilities into their learning management system (LMS) as they were shared "between several users" (Kaptelinin & Nardi, 2006, p. 272). According to CAF-FCA (2013), "LMS applications make it simple for instructors to host learning resources online and to refer students to those resources" (p. 27). Therefore, a LMS could be used to manage and organize information and to test apprentices' understanding of the information presented in a collaborative online learning environment (ITA & VCC, 2007). However, Amp from Institution Two reported that some ODL activities did not integrate well with TLM because of the wide range of user hardware and software (e.g., Adobe® Flash Player).

Characteristics of ODL apprenticeship training. Human interaction with computer technology in an ODL learning environment accommodated different learning styles and enhanced the usability of activities (Baerentsen & Trettvik, 2002). All of the instructors in the study noted that ODL apprenticeship training allowed for online activities that could be both synchronous and asynchronous in delivery. In addition, asynchronous delivery provided recorded lectures for both online distance and in-class students. Instructors agreed that synchronous delivery allowed them to participate in live discussions, assist students in activities, and respond immediately to student questions.

Rules and regulations. The rules and regulations were the "social interactions and coordination related to the use of target technology" (Kaptelinin & Nardi, 2006, p. 273). It was evident from the instructors that the rules and regulations determined how the curriculum was delivered and normally did not dictate what activities were used to teach the curriculum since the content was set provincially. Instructors noted that there was no policy framework for implementing online learning using different technologies in apprenticeship trades training; as CAF-FCA (2013) noted, there were no policy frameworks or agreements "among apprenticeship instructors on the merits of simulation technology" (p.17). However, according to CAF-FCA (2013), the "lack of a policy framework, prohibitive costs, and copyright issues may pose barriers to expanding the use of online learning in Canada" (p. 3).

The rules and regulations related to the social interaction insofar as they could transform the activity (Kaptelinin & Nardi, 2006) in an ODL environment. The design and content of apprenticeship trades programs had to meet the "rules [that] mediate the relationship between the subjects and the community . . . in which they participate" (Jonassen & Rohrer-Murphy, 1999, p. 75). According to CAF-FCA (2013), "there is no consensus in the apprenticeship community on the role of online learning" (p. 4). Therefore the rules including industry accreditation, competencies, and organizational policies that governed all activities in ODL apprenticeship trades education roles were not consistent among the apprenticeship community.

Resources. Interviewees noted that their provincial apprenticeship branches initially funded the ODL programs. They set up rules for enrolment based on the industry need for apprenticeship training which required funding. ODL apprenticeship programs were becoming more affordable as during “the past decade, the sharp decline in computing costs has reduced the cost of creating simulation systems” (CAF-FCA, 2013, p.16).

As the programs evolved, other resources became available, including funding from the industry (i.e., large corporations, manufacturing plants, and oil companies) so that the rules and regulations normally did not restrict who could enroll in an online distance apprenticeship program. In some cases remote training was implemented at employers’ work sites through collaboration and partnership with the training institution (ITA & VCC, 2007). In these situations, employers could teach apprentices by following the institutions’ learning objectives, training tasks, and instructions about how to assess students’ hands-on skills (ITA & VCC, 2007) which lowered the “costs for governments and apprentices, and [decreased] the disruption of the workplace for employers” (CAF-FCA, 2013, p. 4).

The interviewees noted that their individual institutions set their own policies and procedures regulating social interaction and coordination related to the use of the online technology such as requiring students to attend an orientation session. According to CAF-FCA (2013), “it may be important to screen or counsel students before registering them in an online course to ensure they have the motivation to complete the work on their own” (p. 22). The instructors from Institutions Two and Three stated that these orientation sessions were intended to increase students’ completion rates and to make it easier for the students to understand the technology. They found that some students needed extra time to familiarize themselves with the technology that was used in activities.

Learning with the Online Distance Apprenticeship Trades Programs

The research sub-question "how might online distance apprenticeship trades programs affect training competencies and can these competencies be addressed in specific training activities?" explores how learning, cognition, and articulation were the "internal vs. external components of activity and support of their mutual transformations with target technology" (Kaptelinin & Nardi, 2006, p. 270). According to Kaptelinin and Nardi (2006), "the internal (mental) and external components are the processes that can transform the human mind to its social and cultural environment" (p. 68). The learning, cognition, and articulation in an ODL apprenticeship program could be referred to as cognitive apprenticeship. It could also be described as "learning that occurs as experts and novices interact socially while focused on completing a task" (Dennen, 2003, p. 813). Programs that affect training competencies using computer systems "should support the new ways to facilitate problem solving" (Kaptelinin & Nardi, 2006, p. 271) in order to to optimize learning in an ODL apprenticeship trades program. All the instructors described the effectiveness of ODL activities in terms of three learning elements: access to knowledge, time and effort to master new knowledge, and use of shared representation to support collaborative activities (Kaptelinin & Nardi, 2006).

Access to knowledge. Instructors described how the training materials of ODL students were accessible online and could be ordered online. According to CAF-FCA (2013), technical materials such as "technical glossaries, codes, standards and product catalogues are available online, and employees, including apprentices, are expected to find these sources using the web" (p. 5). Some of the technical training terms and concepts were available online which "enable[d] apprentices to review a definition in a timely way" (CAF-FCA, 2013, p. 23). In addition, ODL assignments might "require students to locate resources on the web" (CAF-FCA, 2013, p. 4). In some cases, instructors noted that ODL materials could also be purchased and printed through the institution's bookstore or ordered from the provincial government agency. Instructors said that some students found the printed materials beneficial when they were working in the field camps without Internet access. Access to the printed materials allowed them to continue to study.

According to CAF-FCA (2013), there had been "an increase in the amount of theoretical knowledge that a journeyperson needs, especially in the maintenance and operations trades" (p. 3) which resulted in a need for apprentices with stronger cognitive skills. Seely Brown et al. (1989) noted that knowing and doing are equally necessary in an apprenticeship program and concluded that "the physical skills usually associated with apprenticeship embody important cognitive skills" (p. 39). Therefore, ODL apprenticeship students had to complete all of the labs that face-to-face students did. According to CAF-FCA (2013), while "online learning can reduce the amount of in-school time required for apprenticeship training, it cannot eliminate the need for in-school instruction altogether because the trades, by their nature, require 'hands-on' learning" (p. 22). The face-to-face laboratories used in a blended ODL apprenticeship program enhanced psychomotor skills, but Dennen and Burner (2008) pointed out that apprenticeship learning also involved a cognitive focus that was not strictly limited to psychomotor skills.

Constructivism is a philosophy of education and a cognitive learning theory that assumed that meaning arose from the interaction between an individual's experiences, social interactions, and ideas (Crotty, 2004; Jonassen & Rohrer-Murphy, 1999). Constructivism supported apprenticeship training as it emphasized the construction of knowledge by the apprentices. Collins et al. (1988) described cognitive apprenticeship as "learning-through-guided-experience on cognitive and metacognitive, rather than physical, skills and processes" (p. 456). In the CAF-FCA Report (2013) it was argued that instructional technologies, such as simulations, could enhance “the apprentice learning experience during the theoretical training with more ‘hands-on’ opportunities without risking safety or damage to actual equipment” (p. 3). Simulation technologies were used by the instructors because they reduced risk and costly mistakes. In the CAF-FCS Report (21013) it was also noted that the use of simulations provided safety to the student, resulted in “lower operation costs than actual equipment, and [had] the ability to detect and correct errors before they [became] embedded habits” (CAF-FCA, 2013, p. 4). Instructors identified a number of simulation activities that they had used in the ODL electrical apprenticeship programs that enhanced the apprentices’ learning. The ODL simulation activities that instructors described included a fire detection simulator program, an electrical power service sizing simulator, and an electrical motor simulator. Many of these simulation activities required good Internet connections to enable students to interact with equipment and to receive feedback in real time. The simulations followed the process for diagnosing a problem and presented questions throughout the process. If the student provided the wrong answer, the simulation prompted the student to review the information. In some simulations as the student progressed through the activity, the problems became more difficult. However, according to CAF-FCA (2013), the “apprenticeship training deliverers that use simulation technology do not claim that a simulated environment is a full substitute for actual experience using real machinery and equipment in a work setting” (p. 17).

Vygotsky’s (1978) theory was applied to learning that occurred in a social context to demonstrate how learning by doing—similar to apprenticeship trades training—created learning environments conducive to acquiring complex skills by applying both cognitive and psychomotor skills training. Constructionism, a learning theory developed by Seymour Papert, described knowledge as constructed (not created) through interactions with the environment;

knowledge thus was developed within a social context (Crotty, 2004; Hay & Barab, 2001; Jonassen & Rohrer-Murphy, 1999). The interviewees explained that many training activities in the apprenticeship trade involved some form of constructionism. Activities such as fire alarm simulations provided constructionist learning opportunities for students by enabling them to "interact with animated software replicating an operation of equipment, and to receive feedback on their input in real time" (ITA & VCC, 2007, p. 43).

Hands-on, practical training was a distinct part of apprenticeship trades training and included demonstrating the operation of equipment or the building of an object (ITA & VCC, 2007). In programs with only ODL electrical apprenticeship training, the face-to-face component allowed for supervised hands-on construction of objects (ITA & VCC, 2007). The in-class laboratory experiments and hands-on activities were supervised by the instructor. After the student completed practical, hands-on skills or "lab experiments," the instructor evaluated skills and competencies. In some cases, the student's practical, hands-on training was provided only by his or her employer (i.e., electrical master journeyman) and the apprentice's employer signed off that skills were completed. The practical hands-on component did not need to be completed in a traditional classroom environment (ITA & VCC, 2007). For face-to-face and blended ODL electrical apprenticeship programs, students had access to lab environments providing hands-on experiences with real objects and experiments.

In addition to constructionism, apprenticeship learning was also considered to be the result of reconstruction rather than the transmission of new knowledge as is the case in constructivism. But the idea was extended through the use of manipulative materials to build products from which the construction of knowledge occurs. Therefore, the blended ODL environment apprenticeship offered both cognitive and psychomotor training.

Time and effort to master the new knowledge. According to the instructors, the amount of time and effort devoted to learning to use the online technology impacted the students' learning. Because a higher level of skill was demanded in apprentice work than had been the case in the past thus requiring "more advanced computer literacy than in the past" (CAF-FCA, 2013, p. 8), online multimedia activities often required extra time and effort to learn how to function in and apply the online learning environment.

According to CAF-FCA (2013), if the student was self-disciplined, "one of the advantages of online learning is that apprentices can learn at their own pace" (p. 22). "[T]he nature of the work trades people do is demanding a higher level of skill and more advanced computer literacy than in the past" (CAF-FCA, 2013, p. 8). Therefore, the time required to learn how to use the technology needed to be part of the curriculum. In fact, the instructors reported that this time was reduced significantly after the students completed their first-year apprenticeship program through taking online classes.

Although simple online tasks worked well to support low-level learning, the learning environment design needed to involve more complex tasks, particularly those requiring some form of human interaction (Bonwell & Sutherland, 1996; Kaptelinin & Nardi, 2006). Learning a practical task could be the objective of an activity which could be: physical, such as constructing a house; soft, such as creating computer simulations; or conceptual, such as grasping and applying a theory (Jonassen & Rohrer-Murphy, 1999). According to CAF-FCA (2013), "in some trades, apprentices will need more advanced skills in order to keep up with emerging technologies and more sophisticated pieces of equipment" (p. 5); therefore, activities initially designed for the ODL environment were also used in the face-to-face courses. No differences were reported between face-to-face and online learning objectives.

Student success with the ODL apprenticeship program included online learning environment collaborative activities that allowed students to internalize, understand, and remember material (Bonwell & Sutherland, 1996) such as the use of end-of-module review tests and guided corrective feedback. Evaluations after each completed module allowed students to assess their comprehension and gage their preparation to write their graded final exam (ITA & VCC, 2007).

Representation. It was evident from the instructors that the online learning environment helped in self-evaluations through the use of end-of-module review tests and guided corrective feedback. According to CAF-FCA (2013), apprenticeship online "training programs are experimenting with new technologies to improve knowledge transfer and retention [as well as] responding to industry demand and new approaches to engaging students in the classroom" (CAF-FCA, 2013, p. 2). In addition, the activities that were provided online needed to be "seamlessly integrated with assessments" (Reeves, Herrington, & Oliver, 2002, p. 564). According to the six instructors in my study, the exams for ODL allowed students to assess their comprehension and gauge their preparation to write their graded final exams that were based on real-world tasks.

Development of Online Distance Apprenticeship Trades Programs

The research sub question "how might the effect of implementation of online distance apprenticeship trades programs influence the design of future apprenticeship trades programs?" examined the idea that "activities undergo constant developmental transformations" (Kaptelinin and Nardi, 2006, p. 271). Therefore, the development of online distance apprenticeship trades programs analyzed the history of the ODL apprenticeship trade programs activities to "help reveal main [contributing] factors that [influenced] the development" (p. 271) of online learning for the apprenticeship trades. It was evident from all of the instructors that the designs of both past and future apprenticeship trades programs were influenced through two areas: (1) effects of implementation of the technology and (2) the changing apprenticeship community attitude toward technology.

Effects of implementation. Instructors from the study noted that when ODL electrical apprenticeship programs were first implemented, instructors combined their resources in terms of the teaching and the learning of online design structure. Instructors were looking for ways to take advantage of the available technology, activities, and computers. Initially, during the design implementation process there was some heated discussion among the instructors with some background in design and the instructional design subject matter experts (SME). The disagreements were related to the activity design "goal setting to [learning] outcomes" (Kaptelinin & Nardi, 2006, p. 272) which did not effectively match the activities suggested by the SMEs. This resistance included others within the apprenticeship community (i.e., face-to-face instructors, employers, industry, and electricians) and resulted in some negative feelings among the non-online instructors, who felt threatened. In fact, "one factor that may account for resistance to the use of simulation technology is its introduction as a *fait accompli* without any input from instructors" (CAF-FCA, 2013, p. 17).

Apprenticeship community attitude toward technology. According to Kaptelinin and Nardi (2006), resistance was a "rupture in smooth flow" (p. 232). Resistance introduced conflict (Kaptelinin & Nardi, 2006) during the design, development, and delivery of ODL. It was evident from the responses of the interviewees that the face-to-face instructors sometimes felt that the quality of the apprentices taught by ODL was questionable, perhaps attributable to a lack of understanding about how the ODL program was delivered. However, according to CAF-FCA

(2013), among the apprenticeship community "there is a proactive desire to develop a better understanding of the challenges and opportunities technology poses for apprenticeship training in Canada" (CAF-FCA, 2013, p. 2) which in time would reduce this resistance.

Two of the six instructors noted that once the apprenticeship community learned that the educational goals were attainable through the use of ODL, they became more receptive to the online technology, particularly to a blended learning environment. According to CAF-FCA (2013), with the reduced up-front ODL design costs, the increased number of firms offering course development services, and the increased number of successful pilot lessons learned, the apprenticeship community "adopted a more positive attitude toward e-learning solutions for their training needs" (p. 12).

It was evident from the instructors' responses that the training institutions received additional support and feedback from the apprenticeship community once it saw the demand for flexible apprenticeship training, was assured that the quality of the program was not compromised, and realized that the training could help with the electrical apprenticeship trade shortages. Their feedback directly influenced changes that were made to the structure of the ODL activities (Kaptelinin & Nardi, 2006). According to the instructors in the study, online instructors and students felt that they were part of the school community and were treated fairly when compared to their counterparts in the face-to-face electrical apprenticeship program.

The apprenticeship community included the unions and the collective agreements for instructors who taught ODL apprenticeship programs. Several instructors explained that their collective agreement restricted the number of contact hours per year for instructors teaching within the apprenticeship trades. Working on evenings and weekends violated the collective agreement. Apprenticeship instructors who taught both face-to-face and online had additional contracts (i.e., separate teaching contracts to teach continuing education courses).

Student Assessment and Achievement Levels

The research sub question "how might the development of online distance apprenticeship trades programs affect the instructors' abilities to measure student assessment and achievement levels?" investigated the student assessment and achievement levels involving the zone of proximal development (ZPD) which allowed instructors to measure students' levels of individual development by comparing what students achieved on their own with what they achieved through instruction (Kaptelinin & Nardi, 2006). It was evident to the instructors that the ZPD for ODL electrical apprenticeship trades programs involved students learning through their self-directed activities, which included assessments and scaffolding.

Assessments. It was evident from the instructors who participated in the study that online learning environments lent themselves to self-directed student achievement. Throughout the apprentice learning process, larger and more complex skills were broken down into smaller ones. The assessments were performed to determine progress toward course objectives and to measure the ability of the students to tackle more complex problems that would allow them to develop certain abilities in order to reach a certain skill level. The formative evaluations were held at every stage (mainly after each module) to prepare the student for the final TQ exam and the IP final exams. Supports were provided so that tasks given to apprenticing learners were within their ability levels or ZPD (Vygotsky, 1978). According to the instructors, exam limitations included the type of exams, project presentations, written papers, and the ability to test verbally. As for complex problem-solving such as calculus questions, the type of LMS used had a significant effect on the way the exams were assessed.

Scaffolding. Vygotsky (1978) suggested that strategies such as scaffolding should be used to enhance learning within the ZPD by structuring an activity differently so that the learner could perform the activity at a higher level by using the knowledge of others. It was evident from the instructors that scaffolding was achieved by giving the students the material and asking them to read it and to complete the study questions. According to CAF-FCA (2013), "the level of complexity can be altered when they were using a simulator so that tasks become progressively more challenging" (p. 17).The scaffolding process allowed the students to enhance their learning.

Affordances

The main research question was "how did the affordances of online distance learning (ODL) technologies enable or constrain instructors who were teaching in an apprenticeship trade ODL program?" Affordances were what individuals could do with objects and could be restricted to internal or external influences such as physical characteristics and individual behaviors while solving problems, as well as specific beliefs that might influence the creation of or constrain the use of online technologies (Kaptelinin & Nardi, 2006). The inherent affordances of ODL technologies (e.g., authenticity, construction, flexible teaching, access to apprenticeship trades, and remote training) had implications for instructors who were teaching in apprenticeship trade ODL programs.

Affordance 1: Authenticity for the apprenticeship trades. Training activities in apprenticeship trades ODL programs should ideally have focused on solving relevant real-world problems (Sawyer, 2006) through real-world, authentic activities (Reeves, Herrington, & Oliver, 2002). According to the CAF-FCA Report (2013), in many online activities for the electrical and mechanical trades, "the emphasis is on the electronic components that trades persons must know how to troubleshoot and repair" (p. 8). Those ODL activities could be authentic with real-world tasks using educational technologies such as videos, animations, and simulations. Those technologies allowed for real-life problems in an online learning environment for the electrical apprenticeship program.

Use of online activities in the ODL electrical apprenticeship programs afforded several benefits: they (a) were used for both face-to-face and ODL environments; (b) presented an opportunity for students to practice without making costly mistakes in the laboratory; (c) minimized harm to students, equipment, and facilities thereby reducing liabilities; (d) provided realistic graphics, videos, and the recorded voice of the instructor; (e) clarified confusing issues, such as electrical meter equipment reading discrepancies; (f) reduced the time needed to learn how to use the real-life equipment; and (g) lowered operating costs.

The constraints for online activities for ODL electrical apprenticeship programs were that (a) they required a powerful Internet connection that could handle large file sizes and bandwidth, (b) they required a reliable Internet connection, and (3) they often required preliminary training.

Affordance 2: Construction. According to the constructionism learning theory, which described knowledge as constructed (not created) (Kafai, 2006), learning best occurred when people constructed objects. Utilizing simulations, teachers could design activities for the students to apply their knowledge in a virtual environment prior to applying it in real-life environments. Such activities might include troubleshooting in many manufacturing settings, which "often requires an understanding of computer interfaces and electronic control systems as well as traditional trade skills" (CAF-FCA, 2013, p.11). The use of technologies in ODL environments could assist the instructors' teaching methods by providing a more efficient method for early detection and correction of student errors (CAF-FCA, 2013) before the student could work on real-life situations. However, constraints could occur when an ODL apprenticeship instructor wanted students to learn how to use a tool in real-life, but the ODL technology activities had specific limitations that interfered with the instructor's ability to convey the intended message. According to Engeström (1999), the basic contradiction in an activity system resulted from the tension or conflict between individual actions and individual goals; therefore, the psychomotor and tactile skills could be constrained when applied to real-life situations.

Affordance 3: Flexible teaching environment. From the instructor data, it was evident that the online environment offered instructors some flexibility in teaching, as it allowed them to have a flexible workday, freed them from having to be in the classroom physically, and allowed them to teach anywhere. In fact, this may generate increased access for specialized instructors who are located elsewhere to teach the program which could lead to new instructor employment opportunities.

However, the data from the instructors also contained a number of constraints for instructors teaching ODL: (a) they had to shift from a structured class timetable to a flexible schedule; (b) their hours of work violated the collective agreement, as they sometimes had to engage in a synchronous activity outside of normal working hours; (c) they often did not have network support during off-hours; and (d) face-to-face campus instructors sometimes made jokes at the online instructors' expense as well as being indifferent to, or unaware of, what happened in the online learning courses.

Affordance 4: Access to apprenticeship trades training. The online environment offered students access to a new set of skills in the trades by accommodating different types of learners, opening the door for students to attend technical schools, and minimizing work disruptions. The enablers of ODL electrical apprenticeship programs included: reduced government funding since employment insurance was not required while the student was still working, savings in travel costs, and advantages for younger students over their older classmates as they were more computer-proficient. However, students who worked in remote locations such as field camps without Internet had their access to the ODL apprenticeship trades training limited.

Affordance 5: Remote hands-on apprenticeship trades training. Since many employers “continue to attach primary importance to the practical skills and the dexterity skills of trades persons and they expect the apprenticeship systems to focus on these skills rather than on theoretical skills” (CAF-FCA, 2013, p.11), the employer played an important role in the student’s practical, hands-on training. The ODL offered students remote, hands-on apprenticeship trades training that allowed them to save travel costs, continue to work, and spend increased time at home. The employer signed off on the hands-on experiment training activity log books on behalf of the employee after the experiment tasks were completed at the workplace.

However, there were several constraints: (a) the employer may have been specialized and provided the student with limited skills learned at the worksite, (b) remote training required more collaboration from the government and industry with institutions in order to provide additional continuing education courses, and (c) the employers training the apprentices may have needed additional professional development to hone their teaching skills. Remote hands-on apprenticeship trades training for the ODL apprenticeship program made the employer accountable for the employee’s practical, hands-on skills assessments.

Significances of the Affordances

The significance of the affordances for ODL electrical apprenticeship programs was that they contributed to practice by providing insight into the application of ODL methods to apprenticeship trades education in Canada. Specifically, the research and interviews from the six instructors revealed the design and development of ODL apprenticeship trades learning programs and the factors that led to slow adoption of such technologies.

The affordances described the extent to which students gained the time to think through and respond to sequential, reality-based stimuli (problems, for example) with the ability to repeat, review, or explore the many conditions of a given situation in a cost-effective and physically safe environment. In addition, ODL was expected to improve access to apprenticeship training and minimize work disruptions. It was evident from the instructors that ODL offered flexibility to them as they did not have to be on campus or near the institution and to the learners as it could accommodate the different types of learners and open the door for students to attend technical schools. Finally, there was the importance of the support from the Canadian apprenticeship trades education community, which included apprenticeship instructors, members of the trades industry, workplaces, students, government, and educational institutions. The apprenticeship community influenced the design, development, and delivery of the ODL electrical apprenticeship program.

Research Questions Mapping to Activity Theory Principles

Mapping the activity theory principles to the research sub-questions was an effective way to answer the main research question, which focused on the affordances of online distance learning technologies that enabled or constrained instructors who teach in an ODL electrical apprenticeship trade training program.

The principle of the hierarchical structure of activities was mapped to the research sub-question of how the affordances and constraints might affect the design and development of ODL apprenticeship trades training programs, including the extent to which online technologies are applied in the apprenticeship programs. Applying this principle allowed the research to explore how ODL technology limitations and possibilities and the apprenticeship community influenced the design and development of the online electrical apprenticeship programs.

The principle that addressed the social and physical aspects of the environment was mapped to the research sub-question that asked in what kinds of social and physical environments online technologies integrate with tools, resources, and social and cultural rules. Applying this principle allowed the research to identify the characteristics of learning environments necessary for such integration, such as ODL importance, characteristics of ODL apprenticeship training, rules and regulations, and resources.

The principle of learning, cognition, and articulation was mapped to the research sub-question that asked how the online distance apprenticeship trades program might affect competencies and how those competencies might be addressed in specific training activities. The research derived from this principle provided a better understanding of training activities' internal and external components, such as access to knowledge or access to the printed materials that allowed students to continue to study.

The principle of the history and development of activities was mapped to the research sub-question on how the implementation of ODL apprenticeship trades programs might influence the design of future programs. The research in this area identified two influences on the past and future apprenticeship trades programs: the effects of implementation of the technology and the changing apprenticeship community attitude toward technology.

The principle of scaffolding and student achievements was mapped to the research sub-question of how the development of online distance apprenticeship trades programs might affect the instructor's ability to measure students' achievement. The research aligned with this principle provided an understanding of the instructor's use of scaffolding for enhancing student learning within the ZPD which included assessments and scaffolding.

Recommendations for Apprenticeship Model Change

The findings of this study indicated that with provincial government leadership support at the ministerial level, ODL apprenticeship programs have the potential to increase access to the apprenticeship trades and may contribute to addressing trade skill shortages. With support through collaboration from government, industry, and academic institutions, ODL could become an important part of apprenticeship trades training. To facilitate this, employers, society, training institutions, and instructors must devise an apprenticeship model to address the learners' needs and meet the industry's demands. These stakeholders should consider developing a flexible, apprentice-centered model for centralized access to online activities using educational technologies that are authentic, relevant, accessible, and reliable. I recommend that a new model be considered that includes features of educational technology such as simulations, animations, and virtual reality as key elements for apprenticeship training. The educational technology activities could be located within a repository that has limited license access for the apprenticeship community (i.e., instructors, workplace employers, industry, and students). The educational technology contributors and users would all agree to copyright and intellectual property regulations. The repository would be managed by an organization free from conflict of interest such as government, including educational institutions, provincial crown agencies, or the provincial government ministry. The five major elements of this adaptable apprenticeship trades training model (AATTM) are theory, hands-on/ practical, experimental activities repository, accreditation, and post-journeyperson professional development (Figure 6-1).

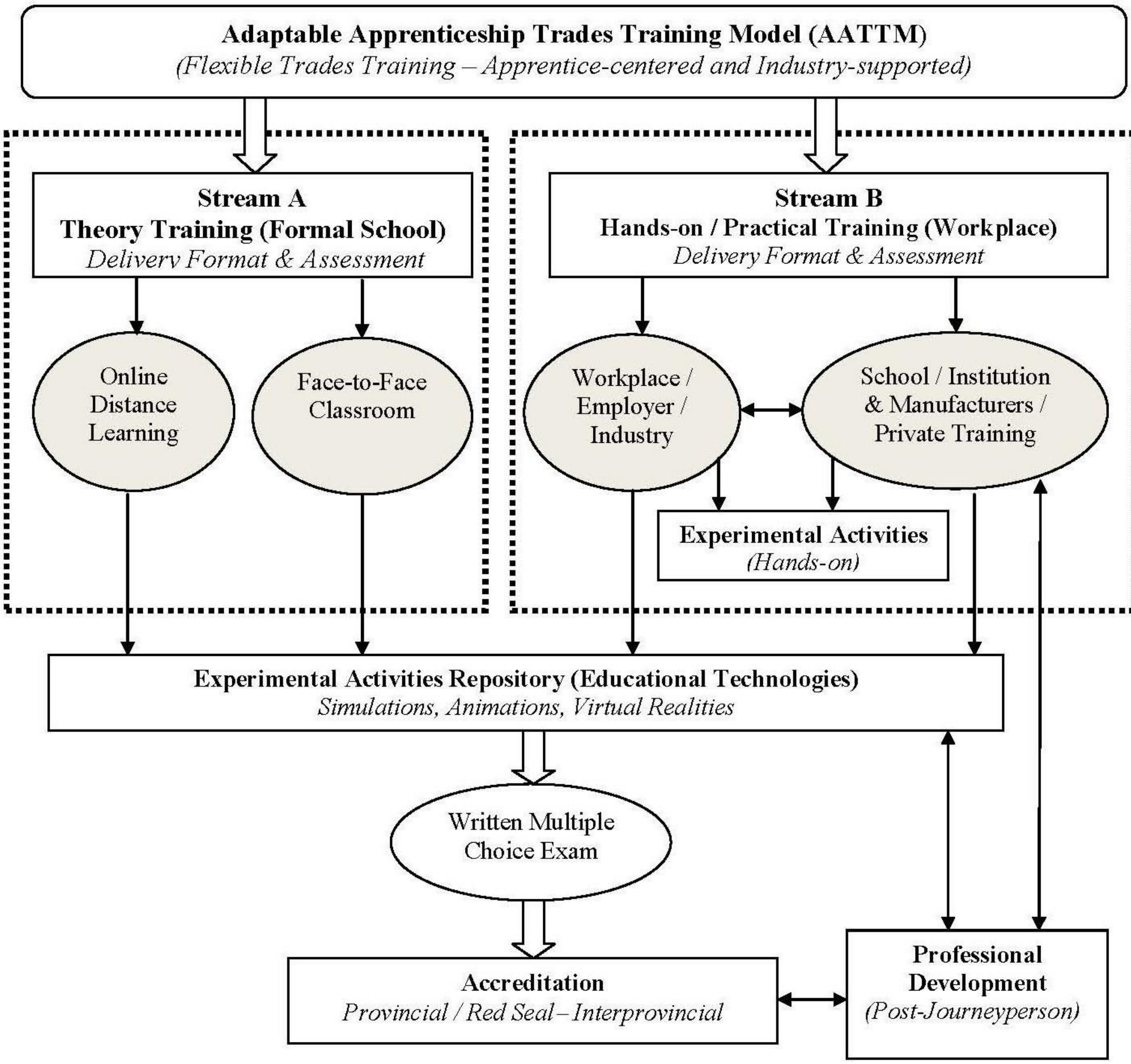

Figure 6-1. Adaptable apprenticeship trades training model (AATTM). Designed and Developed by Bob Sochowski.

Apprentices enrolled in a training program based on the AATTM would have to complete two training streams for their trade (the same as in the current apprenticeship model). Stream A would include the theory element, which could be delivered by either ODL or in a face-to-face classroom and could be offered by formal public trades institutions/colleges, private trades schools, or high school pre-employment programs. Stream B would include the hands-on, practical training component which could be provided at the workplace by the employer. Prior to starting the theory training, the majority of an apprentice's time must be spent working for his or her employer and developing hands-on skills. The hands-on, practical training would be offered at the workplace by the employer, industry, trades institutions/colleges, or private trades schools.

Within the training curriculum for both streams, the apprentices would have to perform a number of experimental activities. Those experimental activities would be completed by using educational technologies and/or equipment in a laboratory and in the field. All of the experimental activities would be centralized for access to the apprenticeship program in both streams. For example, the formal part of training would be the theory stream which would be delivered by public or private institutions either online or in an on-campus, face-to-face classroom. Instructors using either delivery method might choose to supplement the apprentices' learning with an experimental activity, such as using a simulator for diagnosing a fire alarm system. Those educational technology activities would be accessible within the experimental activities repository.

As for the hands-on stream at the workplace, students would rely either on their employers for hands-on training and assessments or, within some apprenticeship trades, the apprentices could attend a school laboratory where instructors would coach students and sign off on their completed hands-on competencies. In addition, the workplace employer might request access to the experimental activities repository for training their apprentices. Once students had met the required amount of training and completed the required hours at the workplace, they might be ready to complete their Red Seal Inter-provincial (IP) exams and then become journeypersons. After the students had successfully completed these exams, they could practice their trades in any province.

To further enhance their skills and stay current of their trades, post-journeypersons could take professional development courses and training activities using educational technologies such as simulators, animation, and virtual reality. Courses and training activities would be available at public or private institutions/colleges, trades' schools, and even within the industry (i.e. manufacturers and private trainers). The educational technologies offered at institutions/colleges and perhaps online could be accessed from the experimental activities repository and be available as options for post-journeypersons, thus making it easier for them to acquire the new knowledge. Currently, the responsibility for staying abreast of current developments and accessing relevant training within their trade rests with the post-journeyperson. Perhaps further consideration should include a formal accreditation regulation that could help facilitate the apprentice's professional development in a structured environment that involved self-regulation by the trade in order to establish professional accreditation similar to that required by other professionals (i.e. professional engineers).

The major change with the new proposed apprenticeship model compared to the existing traditional apprenticeship model is that there would be more focus on access to experimental activities using educational technology. By increasing access to the experimental activities, instructors and the apprenticeship community would make it more cost effective to adopt a flexible apprenticeship training model. In addition, the existing model does not include any formal or regulated professional development for trade journeypersons. Online educational technology would make it easier for journeypersons to access the training during busy working schedules. Thus, the new model would facilitate professional development through continuing education training that would provide journeypersons with knowledge of the latest techniques and technologies as well as to apprise them of regulatory and industry changes.

Implications

Opportunities for using ODL for electrical apprenticeship trades training that impacted the design, development, and delivery of ODL to stakeholders in the electrical apprenticeship training programs, including the government, apprenticeship trades industry, educational institutions, instructors, and students were identified in this research.

Government. The government ministry for higher education (i.e., advanced education and skills training) sets policies and guidelines and allocates funds for skills training. The government viewed skills training as directly related to shortages of skilled labor or to employment opportunities for the unemployed. According to ITA and VCC (2007), there was a compelling need for more flexible delivery of apprenticeship trades training in Canada “for demographic, cost effectiveness and labor supply reasons” (p. 33). In Canada there were apprenticeship trades skill shortages, and industry and government needed to find ways to fill apprenticeship trades positions effectively and efficiently. The labor supply for apprenticeship trades education was important to the Canadian economy and the shortage of skilled trades people had become critical in some foundational trades such as plumbing, electrical, and welding that were vital to local communities (Boothby & Drewes, 2006). There were also many unemployed Canadians who might benefit from apprenticeship training to establish careers. This was confirmed in data from the 2006 Canadian Census which highlighted the need for educational access and retraining in apprenticeship trades (Canadian Council on Learning, 2009).

One way to fill this gap was to review how the existing apprenticeship model fit with available technology and the ways people learned. Hartwig (2007) noted the need for a flexible apprenticeship trades training model and asserted that the need arose from the cost of training, the shortage of postsecondary seats in trades courses, and the changing workforce. As such, there were three key implications to be addressed at the government level.

First**,** research conducted and funded by the Canadian government supported Hartwig's (2007) finding that the high costs of training limited access, thereby partially causing the shortage in skilled trades people and the high demand for flexible apprenticeship trades training (Canadian Council on Learning, 2009). It was evident from the interviews of instructors in this research that flexible apprenticeship trades training that included educational technology activities was not consistently delivered and that online delivery issues continued to make the apprenticeship community skeptical. The study supported the implication that the current apprenticeship model did not lend itself easily to the use of educational technologies without significant intervention and resources from the governing bodies. According to CAF-FCA (20-13), lowering the costs for both the students and the institutions would enable the further expansion of online learning for apprenticeship trades training. The consistency varied between the provinces and within the same province regarding the types of activities used within the apprenticeship trades. For example, different instructors might have used different ways to teach the fire alarm system and one instructor might have access to a simulator whereas the other instructors were not aware of that technology.

Second, according to ITA and VCC (2007), there was strong evidence that when a well-designed and properly funded online learning apprenticeship trades training program employed best practices, the program brought measurable benefits. Furthermore, the industry needed to be a stronger leader for training and needed to take leadership roles through funding and working with government. In the CAF-FCA Report (2013) it was suggested that a provincial policy framework be used for designing, developing, and teaching online apprenticeship programs. Such a framework could include an outline that provides direction and resources indicating how technology could be used and accessed for the instructors' use in their ODL apprenticeship programs.

Third, provincial governments continued to be faced with record deficits and large debts which were not sustainable. Until governments, both provincial and federal, committed to investing more money in innovative apprenticeship training, the apprenticeship trades would continue to struggle. Therefore, long-term strategic planning between the government and institutions was required for the design, development, and delivery of ODL apprenticeship programs. A long-term strategic plan began by determining where the government and the institutions currently stood with ODL apprenticeship programs, and through collaborative discussions between the government and institutions to determine where they needed to be with ODL apprenticeship programs, and finally how both government and institutions could get there (Bryson, 2004).

Apprenticeship trades industry. The apprenticeship trades industry is comprised of suppliers, contractors, installers, and retailers; it is not limited to manufacturers. ODL improved access to apprenticeship training and minimized work disruptions. ODL offered flexibility to learners as it accommodated the different types of learners and opened the door for students to attend technical schools.

Traditional apprenticeship trades training programs were comprised of approximately 80% training in the workplace with the remaining 20%, including theoretical and technical laboratory training, at technical institutes or colleges (ITA, 2011c; Saskatchewan Apprenticeship and Trades Certification Commission, 2011). There were two key implications to be addressed at the apprenticeship trades level.

First**,** ODL training "eliminates the disruption to [company] operations when an apprentice leaves the workplace to attend technical training" (CAF-FCA, 2013, p. 23). ODL programs resulted in an increased number of available, trained skilled workers; minimized work disruption while the apprentices trained; and added more input by stakeholders into the training programs. In order for this to occur, the apprenticeship trades industry participated in and endorsed ODL apprenticeship programs. Their participation included meeting members of institutions' ODL apprenticeship departments and providing feedback on the ODL apprenticeship program.

Second, opportunities involved companies training their own employees and utilizing online activities (i.e., simulations) to augment the students' learning. It was evident from the instructor interviews that some employers, rather than the institutions, provided the hands-on training and signed off the students' competencies. Perhaps a new model for the apprenticeship training might be an apprenticeship program that could adapt to apprentice and employer needs. After the students completed the minimum number of practical hours and their online theory courses, they advanced to writing the final inter provincial (IP) exam, the completion of which earned them the Red Seal journeyperson certification which allowed them to practice their skills in any Canadian province or territory (Canadian Council on Learning, 2009; Red Seal, 2011).

Educational institutions. There were four implications for educational institutions offering ODL apprenticeship training that needed to be addressed if ODL apprenticeship programs were implemented. These implications were (a) infrastructure, specifically, the ability to develop instructors who are capable of designing programs; (b) development and teaching of

ODL apprenticeship courses, (c) the need for instructional design support, and (d) the technology to support the ODL apprenticeship programs.

First, apprenticeship trades programs generally offered a limited number of student seats because the educational model delivered such training in fixed locations (Hartwig, 2007). Unfortunately, educational institutions were unable to accommodate increased student enrolment through increased building capacity, parking spaces, and training locations due to financial constraints (Hartwig, 2007). The physical infrastructure was not able to accommodate the need for increased student enrolment in these trade programs. Therefore, ODL apprenticeship programs helped to “free up classroom space” (CAF-FCA, 2013, p. 23). With proper planning to manage the possible increase of students wanting to take apprenticeship training, institutions with limited funds needed to develop and implement a plan that would include flexible training options for apprenticeship students.

Second, after the initial investment costs for development and design of ODL apprenticeship programs, there would be the potential for institutions to “increase their registrations and expand their pool of potential students” (CAF-FCA, 2013, p. 26). Increased student registration might help with revenue shortfalls. Furthermore, the ODL might increase apprenticeship completion rates. If institutions lagged behind in keeping up with the industry demands for flexible training options, those institutions could lose students to others offering ODL apprenticeship programs, which could result in loss of provincial funding and the institution’s reputation.

Third, another implication was that the institutions must commit to providing support to ODL programs. It was evident from the instructors who were interviewed that success for the ODL apprenticeship programs was directly related to the instructional support from the institution. Instructors might not want to design, develop, and teach ODL apprenticeship programs if there was no support because instructors might see this as extra work without extra pay. If there was a lack of support for ODL programs, instructors could experiment on their own time with modifying existing learning activities by using different technologies to facilitate online delivery which might conflict with the institution's vision and mission statements (Bryson, 2004).

Fourth, institutions might not need to provide additional physical infrastructure, but they would need to supply robust computer infrastructure for the online program. There was a significant initial cost to design, develop, and deliver ODL apprenticeship programs. As activities became more complex, the development costs increased. A strategic plan within the institutions was required for the design, development, and delivery of ODL apprenticeship programs. Without proper planning, there would not be intentional investment in the infrastructure. Such planning needed to include the institution's vision of how the ODL apprenticeship programs would be used which would also include a mission statement that described why online instruction was needed for apprenticeship programs and a strategy for how to implement it within a certain timeframe (Bryson, 2004).

Instructors. Instructors were the front-line workers for apprenticeship training. Their role was to deliver training and to act as resources for students. There were four key implications relating to online learning for instructors.

First, the challenge was to ensure permanent funding for the ODL programs (Berge, 1998; Hartwig, 2007; Rockwell, Scheuer, Fritz, & Marx, 1999). Instructors confirmed that the lack of funding affected the ODL electrical apprenticeship programs though the types of technologies and activities used in an online environment. Instructors needed institutions' financial support in allocating funding for ODL programs. Instructors also needed to become advocates on behalf of the institutions for ODL apprenticeship programs and needed to network with industry which might help to increase funding from industry.

Second**,** it was evident from the instructors that the lack of institutional support decreased instructors' incentive to initiate or sustain online education for the apprenticeship trades (Hartwig, 2007; Wilson, 2001). Institutional support was important since instructors teaching online might be designing, developing, and teaching outside of their collective agreements and as a result might be on separate contracts which could result in the instructors working extra hours without overtime pay or benefits.

Third, as part of the redesign process for existing face-to-face electrical apprenticeship programs, ODL apprenticeship trades instructors faced challenges in designing activities based on real-world problems (Myers, 2003). Therefore, instructors needed to have access to innovative real-world activities using educational technologies that could be delivered online. Instructors also needed to have access to existing online activities such as simulators. Such access might include an online centralized, secured, shared network. This network could be a resource for instructors accessing activities using various types of technologies (i.e. simulations, animations, videos).

Fourth**,** instructors teaching ODL electrical apprenticeship programs had to manage their time effectively to keep the students engaged by adjusting the way they taught to accommodate an online environment. Ways to keep the students engaged included using innovative, interactive activities. According to CAF-FCA (2013), interaction with an instructor for part of the course "motivates apprentices and contributes positively to their performance" (p. 23). Instructors needed to be prepared to provide extra support to students who were struggling with their own time management and motivation (CAF-FCA, 2013).

Students. According to Sparks et al. (2009) **s**tudents were the key to the success of any program and apprentices might demand more flexible learning and training. Students come from many different backgrounds and the implications for them are that they must assess whether they are ready and have the ability to do online distance learning. Instructors will have to adapt the curriculum delivery to the different types of students. As such, the following two implications need to be addressed at the students' level.

First, students needed to be self-directed learners to work outside of a traditional face-to-face classroom and needed to have some technical readiness and the ability to manage working at home. Hence, the instructors provided orientation sessions for the students before they started the ODL apprenticeship program. These orientation sessions helped inform the students about the skills needed to work off-campus, particularly because "apprentices have been out of school for a number of years and adjusting to 'structured learning' can be a challenge" (CAF-FCA, 2013, p. 25). If the students are not self-directed, they will be encouraged to take the face-to-face apprenticeship program or the institution may encourage the student to attempt one course online and decide after that time to change to a face-to-face apprenticeship program.

Second, students expected instructors to incorporate new technologies such as "electronic books, simulations, text messaging, podcasting, wikis, and blogs" (Kim & Bonk, 2006, p. 22) into the curriculum. Some apprentices with a technology background "will adapt easily to online learning and will flourish in an e-learning environment" (CAF-FCA, 2013, p.23).

Traditional face-to-face apprenticeship trades training programs were originally designed to cater to younger students without such commitments as families, mortgages, and aging parents which are common to adult learners. Older students' lifestyles limit their availability for training (Dearnley et al., 2006; Hartwig, 2007; Sparks et al., 2009). Yet those students "who lack basic computer literacy or who do not have online access will be at a serious disadvantage in an institution that operates an LMS application" (CAF-FCA, 2013, p. 27). Without providing these training options, the students' interest in enrolling in the apprenticeship trades may decrease, causing them to drop out and leading to a decrease in apprenticeship completion rates.

Summary

The discussion and implications identified a number of sources of affordances that affected the design, delivery, and teaching of online apprenticeship trades programs. Affordances included the focus of apprenticeship trades ODL programs on solving relevant real-world problems, the ability to construct knowledge, and flexibility in teaching and in course delivery. In addition to affordances, some sources of tension included support (or lack thereof) from the apprenticeship community which may influence the use of technologies in the apprenticeship trades, possible new employment opportunities for instructors; and non-integration of technologies. The five principles of activity theory were used to map the research questions to what is known in the literature. Chapter Seven includes a conclusion and recommendations for ODL apprenticeship trades program training.

Chapter Seven: Summary, Recommendations, and Conclusion

A summary of the multiple case studies that were used in order to learn more about how instructors designed, developed, and delivered online distance learning (ODL) electrical apprenticeship training programs in Canada is presented Chapter Seven. In addition, a number of recommendations have been made for future research and a conclusion has been reached.

Summary of the Study

To understand the impact of online technologies in ODL environments for the electrical apprenticeship trades better, in this research a case study approach was employed to understand electrical instructors' experiences in designing, developing, and delivering electrical apprenticeship trades programs in an ODL environment. The study participants were six electrical ODL apprenticeship instructors from three different public institutions in two provinces. Each case was developed from an interview with the ODL electrical apprenticeship instructor, document analysis, and a review of online materials such as the institution's website and the observation of the program course shell.

Analysis of the data focused on the design and efficacy of activities that relied on educational technologies (Fretwell, 2003; Issroff & Scanlon, 2002; Mwanza & Engeström, 2003). The research focused on activity theory's mediating role in the context of explaining how people use computer technology (Kaptelinin & Nardi, 2006, p. 270). To analyze the data collected from the case studies, the research applied five activity theory principles: the hierarchical structure of activities; the social and physical aspects of the online learning environment; the learning, cognition, and articulation of online activities; the development of online activities; and the zone of proximal development (ZPD) of online activities (Issroff & Scanlon, 2002).

Five inherent affordances were identified which had implications for instructors in apprenticeship trade ODL programs: (1) authenticity for the apprenticeship trades, (2) construction that utilized educational technologies, (3) flexible teaching environments that enabled instructors to work flexible hours, (4) access to apprenticeship trades training for students, and (5) remote hands-on apprenticeship trades training that allowed students to save travel costs, continue to work, and spend increased time at home.

The results from the study indicated that the potential of ODL was not fully realized due to local accessibility issues and instructors' unfamiliarity with the technologies employed. The research also identified factors that had implications for the apprenticeship community, including the government (both provincial and federal), the apprenticeship trades industry, educational institutions, instructors, and students.

Recommendations for Future Research

At the conclusion of the inquiry, more informed questions based on the key issues that emerged from the research were asked. These issues and questions were put forward for further consideration. Each of the issues was listed along with questions to guide future research.

Cross-case study of ODL for apprenticeship trades. This research was limited to the electrician apprenticeship trades in Canada, which opened opportunities for future qualitative studies of ODL programs for other skilled trades (i.e., welding, pipefitting, carpentry) from across Canada. A cross-case study could trace how the ODL activities used in other apprenticeship trades might affect the delivery of the programs. The main research question could be, "How do the types of ODL activities impact the delivery of ODL in different types of apprenticeship training programs?" The research sub-questions could include, "In what ways are ODL activities accessible for instructor use?"

Ethnographical study of an apprentice in ODL training. The research also identified some cultural issues using ODL within the apprenticeship community. Therefore, an ethnographical field study could be conducted to gain insight into the life of an apprentice. The researcher could shadow apprentices for an extended period of time and become more knowledgeable about their day-to-day, school- and work-related experiences using ODL. This study could apply the descriptive approach that relies on observations as the means of collecting data. The main research question could be, “How does the ODL environment affect the apprentice’s learning?” Sub-questions could include, “How does the ODL environment affect the working environment? In what ways does the ODL environment affect the apprentice’s work-life balance? What are the perceptions of the apprentice’s family members relative to the apprentice’s ODL training?”

Comparative ODL apprenticeship study with Canada and other countries. This study was limited to Canada, but other countries such as England and the United States have explored and used ODL for apprenticeship trades training. Therefore, a qualitative study on ODL apprenticeship training in work environments comparable to those in other countries such as the United States and Europe is needed. Such a study could compare the electrical instructors’ design, development, and delivery experiences in Canada with those of electrical instructors in other countries. The research would comprise multiple case studies. The main research question would be, “How do the affordances of ODL technologies enable or constrain electrical apprenticeship trades instructors in Canada compared to those in other countries?” Research sub-questions could include, “How might the affordances and constraints affect the design and development of ODL apprenticeship trades training programs? In what kinds of social and physical environments do ODL technologies integrate with these environments' requirements, tools, resources, and social and cultural rules?"

Influence of instructor credentials on ODL apprenticeship training. In the current study, five out of six instructors had completed a graduate degree and one instructor had a Doctorate. Historically, apprenticeship trades instructors are hired for their trade-specific expertise rather than for their knowledge of program design or pedagogy. Many of them have very little training or experience in designing, developing, and teaching apprenticeship trades courses. This lack of understanding about educational principles could be directly related to the slow adoption of ODL in the apprenticeship trades.

A qualitative study could help identify whether the type of education the trades instructors have influences the use of educational technologies in apprenticeship trades programs. The main research question would be, "In what ways does the apprenticeship trades instructor with graduate degrees influence the adoption of educational technologies within the apprenticeship trades program?" Research sub-questions would include, "Does the instructors' experience with a college education influence the design of ODL apprenticeship programs?"

Government influence on ODL apprenticeship training. The ODL format for apprentice trades education is relatively new in Canada; as a result, many institutions offering apprenticeship trades education have not yet embraced nontraditional forms of training. The data gleaned from this research as well as from the literature review suggested that if government provides a policy framework for ODL apprenticeship programs, then ODL apprenticeship training may become more mainstream. Future research could include a qualitative study to explore the government policy framework for educational technologies for the apprenticeship trades. The main research question would be, "How does government policy influence the adoption of online learning for the apprenticeship trades?" Research sub-questions would include, "In what ways can the government facilitate ODL for apprenticeship programs? What are the completion rates of the face-to-face apprenticeship program compared to ODL apprenticeship? What is the effect of the institutional funding model on ODL apprenticeship programs?"

Affordances of different types of ODL apprenticeship activities. The research identified five inherent affordances that have implications for instructors who are designing, developing, and teaching in apprenticeship trade ODL programs. A qualitative study could be conducted to identify the affordances of the different types of ODL activities in an apprenticeship trades program. This study could be limited to a trade but not limited to Canada, as other countries may have more advanced ODL apprenticeship training activities. The main research question would be, "What are the affordances of the different types of ODL activities in an apprenticeship trades program?" Sub-questions would include, "In what ways does the type of apprenticeship trade influence the design of ODL activities? How might ODL activities affect the training competencies? How might the design, development, and teaching of ODL activities affect their adoption by an apprenticeship trades program?"

Conclusion

This multiple case study used the principles of activity theory to understand instructors' experiences in designing, developing, and teaching activities in an ODL environment for the electrical apprenticeship trades programs. Apprenticeship training historically has been a trades entry point for employment in Canada. With increasing shortages of qualified trades workers in Canada, it is timely to explore opportunities for delivering educational content online with authentic activities mimicking real-world situations. The current research study showed that the

Internet provides students with access to online distance learning in a limited number of institutions that offer electrical apprenticeship trades training. The apprenticeship trades industry and culture initially determined that learning apprenticeship trades skills required practical, physical components, but it was clear from the research undertaken for this dissertation that ODL electrical apprenticeship trades activities could meet the physical, hands-on requirements for assimilating skill-oriented knowledge in blended learning environments.

The research findings from this study are of interest to the apprenticeship trades industry because they support the efficacy of ODL, which provides options that are anticipated to increase the number of qualified trades workers and to assist academic administrators with their strategic planning. From the findings, recommendations can be made that can provide guidance for government policy direction. Further, these findings can be used to assist instructors in gaining a better understanding of their changing roles and responsibilities when designing, developing, and delivering ODL electrical apprenticeship trades programs.

Although the research was focused only on the electrical apprenticeship trades, the results potentially are applicable to other apprenticeship trades. With support from the provincial government at the ministerial level and a well designed ODL electrical apprenticeship program which overcomes technology limitations, ODL apprenticeship programs have the potential to increase access to the apprenticeship trades and may contribute to addressing skilled trade shortages and possibility to reduce unemployment.

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Appendix A – Code Example (Case Study One)

CASE STUDY ONE - NIKE
Hierarchical Structure of Activity *(HSA-1)*

TECHNOLOGY – FUNCTIONS *(HSA-FUNC-1)*

HSA-FUNC-1:1
"Avoid video and because of the size of the video, because of the connection, some people don't have real good Internet connection"

HSA-FUNC-1:2
"We usually have them keep their microphone off because you get feedback sometimes from them, having too many people with their microphone on"

HSA-FUNC-1:3
"I find for student's comfort levels a face-to-face meeting before you start with the online makes them more comfortable contacting me"

HSA-FUNC-1:4
"I do use web tours, I do use application sharing – all very good things that you can do in Blackboard"

HSA-FUNC-1:5
"I think it's just a part of the fact that videos take so much space"

TECHNOLOGY – LIMITATIONS *(HSA-LIMIT-1)*

HSA-LIMIT-1:1
"There is only so much theory that you can teach without having some practical hands-on experience with that topic to help reinforce the learning and that's something that in the classroom they can do"

HSA-LIMIT-1:2
"When it comes to teaching about fire alarms, in real life they are able to hook it up, make it work, and actually see it in action at the same time they're learning the theory part then that is the ideal – and that is the limitation, that we can't."

HSA-LIMIT-1:3
"Simulator can help the learning in connecting them up and actually try them, see if they work, there are addressable systems where you actually put an address for each device and then you know which device is triggered and that sort of thing."

HSA-LIMIT-1:4
"All of those things, if you can't physically do that, then the theory doesn't make as much sense to a student"

HSA-LIMIT-1:5
"I've done a lot of sessions around how to use the Canadian electrical code, how to use the tables, and all that kind of thing. They all are pre-recorded sessions that they can go and watch as many times as they need to, so that flexibility is really good"

Appendix B – Code Example (Case Study Two)

CASE STUDY TWO - AMP
Hierarchical Structure of Activity *(HSA-2B)*

TECHNOLOGY – LIMITATIONS *(HSA-LIMIT-2A)*

HSA-LIMIT- 2A:1
"The biggest limitation is the myopic view of the professional developers in the field of a trades program"

HSA-LIMIT-2A:2
"The primary limitation is the philosophical approach of our professionals to a trades training program"

HSA-LIMIT-2A:3
"There's a lot of technologies out there. They all have their place. They can all be used but the primary limitation is the philosophical approach of our professionals to a trades training programme"

HSA-LIMIT-2A:4
"There really are no limitations in terms of the technology"

CASE STUDY TWO - WATT
Hierarchical Structure of Activity *(HSA-2B)*

TECHNOLOGY – LIMITATIONS *(HSA-LIMIT-2B)*

HSA-LIMIT- 2B:1
"Our course workload works in a year, we're based on the fact that at least the collective agreement for the college as a trades instructor, you go by 650 contact hours a year"

HSA-LIMIT-2B:2
"Complete and direct conflict with our collective agreement"

HSA-LIMIT-2B:3
"What governs us is a fulltime faculty and an online program in direct conflict"

HSA-LIMIT-2B:4
"What governs us is a fulltime faculty and an online program in direct conflict"

Appendix C - Demographics Questionnaire

1. What is your age? ______________
2. What is your gender? (please circle): Male Female Prefer not to say
3. Are you currently employed as (please check):

   ☐ Full-time apprenticeship trades instructor

   ☐ Part-time apprenticeship trades instructor

   ☐ Contract/sessional apprenticeship trades instructor

   ☐ Other (please describe): ____

   ____

4. What is the highest degree or level of school you have completed?

   ____

5. How many years have you taught your apprenticeship trades program in a *face-to-face* learning environment? ______________
6. How many years have you taught your apprenticeship trades program in an *online* learning environment? ______________
7. How many years have you designed and developed *online* curriculum for apprenticeship trades programs? ______________
8. Have you received formal and/or informal training to design and develop *online* learning courses? If so, was it formal or informal?

   ____

9. Indicate which of the following technologies you have used both personally and professionally (please check all those that apply):

   ☐ Mobile Communication

   ☐ Simulation

   ☐ Virtual Reality

   ☐ Video games

   ☐ Digital Storytelling

   ☐ Social Networking/Media

Appendix D – Activity System Eight-Element Model Data Collection Interview Questions Matrix

Activity systems eight-element model. Adapted Mwanza, D., & *Engeström, Y.* (*2003*).

Activity Systems Eight-Element Model	
The following data helped establish the context for the study.	
Step 1: *Activity of Interest*	**Interview Question:** Please describe the activities (i.e., simulations, animations, videos, assignments, etc.) offered in your online distance learning electrical 4th year apprenticeship trades course.
Step 2: *Object and Goals*	**Interview Question:** Please describe the goals or the sub-goals in your course.
Step 3: *Subjects*	**Interview Question:** What was your involvement in designing and developing this course?
Step 4: *Tools*	**Interview Question:** What technologies and materials are you using to teach the course?
Step 5: *Rules & Regulations*	**Interview Question:** Describe the apprenticeship trades training cultural norms, regulations governing the performance of the apprenticeship trades course.
Step 6: *Division of Labour*	**Interview Question:** Who else designed and developed this course?
Step 7: *Community*	**Interview Question:** Please describe the community or environment to which the course is connected.
Step 8: *Outcome*	**Interview Question:** Please describe the desired outcome in the apprenticeship trades course.

Appendix E - Activity Theory Principles Data Collection and Analysis Interview Questions

Matrix

Principle 1 of 5: Means/Ends (hierarchical structure of activity)

Research Sub-Question: How might the affordances and constraints affect the design and development of online distance apprenticeship trades training programs?

	Interview Questions	Research Analysis Objectives
1	Are there any functions in the online technology that are not used? If yes, which functions were not used and why?	Identify limitations and enablers used in an ODL environment.
2	Are there functions of the online technology that are not supported in the technology, but that students and instructors obviously need? If yes, which functions were not supported in the technology and why?	Identify limitations and enablers for determining the types of activities that should be used in an ODL environment.
3	What are the basic limitations using online technology in apprenticeship trades training?	Identify limitations and enablers for determining the types of activities that should be used in an ODL environment.
4	Are there conflicts between face-to-face learning objectives and online learning objectives? If yes, what are the procedures for resolving the conflicts?	Identify limitations and enablers for determining the types of activities that should be used in an ODL environment. Identify ways to encourage collaboration with the apprenticeship trades community in the design of ODL apprenticeship trades programs.
5	How does the apprenticeship community influence the design and development of the online apprenticeship program?	Identify the apprenticeship community's involvement with the design of ODL apprenticeship trades programs. Identify ways to collaborate with the apprenticeship trades community with the design of ODL apprenticeship trades programs.

Principle 2 of 5: Environment (social and physical aspects of the environment)

Research Sub-Question: In what kinds of social and physical environments do online technologies integrate with these environments' requirements, tools, resources, and social and cultural rules?

	Interview Questions	Research Analysis Objectives
6	Please describe the concepts and vocabulary of the online apprenticeship training compared to the concepts and vocabulary of the face-to-face apprenticeship trades training.	Identify role of online technology in producing the outcomes of target action for the activity.
7	Are there any activities in the online technology environment that are initially designed for the face-to-face apprenticeship learning environment? If yes, please identify features from the face-to-face learning environment that add value to the design of online apprenticeship trades programs.	Identify attributes from the face-to-face learning environment that contribute to the design of ODL apprenticeship trades programs. Identify constraints imposed on the program learning objectives by the online technology chosen and used by instructors.
8	From your experiences, please describe how the online technology is an important or not important part of apprenticeship trades training. Please explain.	Determine the technologies used for ODL apprenticeship trades activities.
9	Are there other technologies available within the spectrum of online technology? Please explain.	Determine the technologies used for ODL apprenticeship trades activities. Identify other tools to the user other than the online technology (example: simulations, virtual reality, videos).
10	Please describe your experiences with online technology integration with other tools and technology.	Determine the ability to integrate other tools or technology with online technology (example: simulations, virtual reality, videos).
11	How are apprenticeship trades training characteristics of face-to-face instruction consistent with the apprenticeship trades online training?	Determine the technologies used for online distance learning apprenticeship activities. Determine the appropriate technology to use for ODL apprenticeship activities.
12	How does spatial layout and temporal organization of the online work environment impact the design of apprenticeship trades	Determine the appropriate technology to use for ODL apprenticeship activities.

	training?	
13	How are the apprenticeship learning activities distributed between synchronous and asynchronous?	Determine the technologies used for ODL apprenticeship activities. Determine the appropriate technology to use for ODL apprenticeship activities.
14	What rules and procedures regulating social interaction and coordination are related to the use of the online technology?	Identify the effect that cultural norms, regulations, and rules have on the design and development of ODL apprenticeship activities.
15	What resources are available to design and develop the online distance apprenticeship program?	Determine the appropriate technology to use for ODL apprenticeship activities.

Principle 3 of 5: Learning, Cognition, and Articulation

Research Sub-Question: How might online distance apprenticeship trades programs affect training competencies and can these competencies be addressed in specific training activities?

	Interview Questions	Research Analysis Objectives
16	Explain how the amount of time and effort in learning to use the online technology impacts the students' learning.	Determine the time and effort necessary to learn how to use existing technology.
17	Explain how the online learning environment helps to avoid unnecessary learning.	Determine the time and effort necessary to learn how to use existing technology.
18	How is distributed online material accessible?	Identify the knowledge about online technology that resides in the environment and the way the knowledge is distributed and accessed.
19	Describe how the online learning environment provides representation of students' activities that can help in self-evaluations.	Identify self-monitoring and reflection through externalization.
20	In what ways does the online apprenticeship trades program provide problem representations in case of breakdowns that can be used to find a solution or formulate a request for help from the instructor?	Determine the support needed for problem articulation and help requests in case of breakdowns. Determine suitable activities for apprenticeship trades training that can be taught in an ODL environment. Determine the assessment methods for online apprenticeship trades program activities.
21	Were there pilot tests on the online distance apprenticeship training activities? Please explain.	Determine the use of the ODL apprenticeship technology for simulating activities before actual implementation.
22	Are there group activities within the online apprenticeship trades training? Please explain.	Identify strategies and procedures for providing help to other users of online technology in a collaborative work environment. Determine individual contributions to shared resources of a group or organization. Identify coordination of individual and group activities through externalization.

Principle 4 of 5: Development (History)

Research Sub-Question: How might the effect of implementation of online distance apprenticeship trades programs influence the design of future apprenticeship trades programs?

	Interview Questions	Research Analysis Objectives
23	What was the effect of implementation of online technology for the apprenticeship trades training program?	Identify activities added or deleted after the ODL apprenticeship trades program was implemented. Determine the negative or positive side effects associated with ODL apprenticeship trades programs.
24	In what ways do the instructors have experience and/or training with the online technology at the time of design development?	Determine the negative or positive side effects associated with ODL apprenticeship trades program instructors' influence.
25	Describe your attitude toward use of the technology. Did the online technology show increasing or decreasing benefits over the process of its use?	Users' attitudes toward target technology (e.g., resistance and how they change over time).
26	What were the apprenticeship community's attitudes toward the online technology? Did the apprenticeship community become more or less positive?	Determine attitudes toward the ODL apprenticeship trades programs. Determine instructors' attitudes toward the online technology (e.g., resistance and how they change over time).
27	Describe the negative or positive side-effects associated with the use of the online technology within the apprenticeship community?	Determine the negative or positive side-effects associated with online distance apprenticeship trades programs.

Principle 5 of 5: Zone of Proximal Development		
	Research Sub-Question: How might the development of online distance apprenticeship trades programs affect the instructors' ability to measure students' assessment and achievement levels?	
	Interview Questions	**Research Analysis Objectives**
28	Describe how the learner is assessed. What were the learning assessment limitations of the online technology?	Identify the assessment methods for ODL apprenticeship trades program activities.
29	Describe any scaffolding strategies and how the activities are used to enhance learning.	Identify scaffolding strategies used to enhance learning within the ZPD by structuring an activity differently so the learner can perform the activity at a higher level.

Appendix F – Permission to use Activity Systems Triangle

Sochowski, Robert CITZ:EX

From:	Daisy.Mwanza-Simwami
Sent:	Sunday, May 19, 2013 10:09 AM
To:	Robert Sochowski; daisy.mwanza-simwam
Cc:	Sochowski, Robert CITZ:EX
Subject:	RE: Permission Request to use

Dear Robert,

Apologies for taking time to reply.

We grant permission to re-use the figure as long as you can fully acknowledge the source.

Best Regards
Daisy

From: Robert Sochowski
Sent: 19 May 2013 05:45
To:
Cc:
Subject: Permission Request to use

Dear Prof. Engeström and Prof. Mwanza:

Several months ago, I sent an email to you asking permission to use a figure. As I mentioned in my earlier email, I am writing my doctoral dissertation about online learning in the electrical apprenticeship trades education in Canada. My theoretical framework uses the principles of activity theory to understand the learning experiences in an educational setting, including the instructors' experiences in designing and developing activities in an online environment for apprenticeship trade programs. I would like to have your permission to use Figure 1 and Figure
2 (the activity systems triangle) from your paper "Pedagogical Adeptness in the Design of E-Learning Environments: Experiences from the Lab@Future Project." If this figure has since been published elsewhere and is under copyright protection, please let me know whom to contact to seek permission to use it.

I look forward to hearing from you.

Thank you.

Regards,

Robert Sochowski, MA, BAed
Doctoral Candidate
University of Calgary, Canada