Key Trends and Observations

The Impact of Technology on Apprenticeship Training in Canada

Canadian Apprenticeship Forum
Forum canadien sur l'apprentissage

Canada

About CAF-FCA

The Canadian Apprenticeship Forum – Forum canadien sur l'apprentissage (CAF-FCA) is a national, not-for-profit organization working with stakeholders in all regions of Canada. CAF-FCA influences pan-Canadian apprenticeship strategies through research, discussion and collaboration – sharing insights across trades, across sectors and across the country – to promote apprenticeship as an effective model for training and education. Its Board of Directors is comprised of representatives of business, labour, the provincial/territorial apprenticeship authorities, education and equity. Through its work, CAF-FCA has shed light on a number of key issues affecting apprenticeship, such as the perceived barriers to accessing and completing apprenticeship and the business case for apprenticeship training. For more information, visit the CAF-FCA website at www.caf-fca.org.

Note to Readers

The opinions expressed in this report do not necessarily represent the views or official policies of CAF-FCA or other agencies or organizations that may have provided support, financial or otherwise, for this project.

Acknowledgements

This project was funded by the Government of Canada's Sector Council Program.

CAF-FCA acknowledges the contribution of the Prism Economics and Analysis in completing the research and interviews.

CAF-FCA would like to thank the members of the Working Group and interviewees for the contribution of their time to this project. Their insights were very much appreciated.

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1.1 Report Overview

Apprenticeship training is being impacted by technology in a number of significant ways. 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. Technical training programs are experimenting with new technologies to improve knowledge transfer and retention, responding to industry demand and new approaches to engaging students in the classroom. On-the-job training is increasingly marked by e-learning, vendor training and the use of mobile technology. Among stakeholders, there is a proactive desire to develop a better understanding of the challenges and opportunities technology poses for apprenticeship training in Canada.

This report is an initial investigation of the degree to which apprenticeship training is being impacted by the introduction and implementation of new technologies. The aim of this report is to increase stakeholder understanding of the current landscape and to stimulate further discussion on this topic, allowing the apprenticeship community to strategically address and manage the impacts that technology is having on apprenticeship.

In approaching this topic, this report draws upon secondary source research and interviews. A scan of relevant national and international sources on the topic was completed to better understand current themes and trends. Fifty-one interviews with employers, employer associations, college instructors, and trainers were also completed to gain an understanding of the "on-the-ground" perspectives.

The research is organized around three main themes: industry trends impacting trades and skills requirements, the use and impacts of instructional technologies, and the impacts of e-learning on-the-job.

1.2 Main Findings

The research reveals that apprentices in certain trades are facing new skill requirements associated with complex automation systems. Instructional technologies such as 3-D visualization and simulation are enhancing the apprentice learning experience during technical training, providing more 'hands-on' opportunities without risking safety or damage to actual equipment. The need to find resources on the web, use applications (apps) and learn or track hours online are becoming increasingly commonplace, each requiring higher levels of computer literacy, digital skills, and executive skills, such as self-motivation, self-discipline and time management. These new requirements can pose a challenge for apprentices who prefer more tactile learning approaches. For example, many employers prefer to use online learning for skills upgrading, requiring apprentices and other skilled tradespeople to adjust despite the challenges it may pose for a group more predisposed to hands-on learning.

This report also provides some insights into the challenges that the apprenticeship community may need to address. Lack of a policy framework, prohibitive costs and copyright issues may pose barriers to expanding the use of online learning in Canada. The increasing use of vendor training and training sourced from the United States (U.S.) may pose additional problems for the apprenticeship community, as these trainers may be unfamiliar with Red Seal standards. For those employers who adopt technology early, there is also a risk that existing training standards will not meet their needs.

Based on the literature review and interview input, this report suggests some next steps for the apprenticeship community. Among these, there needs to be broader engagement on the subject of e-learning, possibly leading to the creation of an e-learning strategy. Developing appropriate screening mechanisms to assess capacity and preparedness for e-learning among individual apprentices will be important to ensuring apprentice learners have the necessary supports. Other considerations include developing skills assessments and strategies for technology-intensive industries and ensuring training standards reflect and respond to the realities faced by these employers. Experimentation with e-management systems may offer a new means of tracking and monitoring on-the-job learning. Throughout the research process, stakeholders expressed a desire for information-sharing and discussion, leading to the recommendation that ways to document, evaluate and share innovative practices be developed.

1.2.1 Industry Trends Impacting Trades and Skills Requirements:

The specific trends observed around each of the main themes are summarized below. These industry trends are applicable to a number of trades and sectors:

- An **acceleration of the pace of technological change** such that, in many companies, the technologies in their workplaces have moved beyond the skills that are covered by provincial and territorial trade standards.
- The widespread **incorporation of information and communications technologies (ICTs) into machinery and equipment**. One commentator characterized ICT-driven technological change as "smart everything."
- The **increased importance of technology training**, especially in the manufacturing sector. There is an increase in the amount of theoretical knowledge that a journeyperson needs, especially in the maintenance and operations trades.
- The **increased importance of vendor-supplied training** as a source of skill development in the workplace.
- The emergence of **e-learning as the preferred mode of delivering training among an increasing number of large and mid-sized employers** together with reductions in the cost of developing e-learning products and improvements in their quality.
- The widespread use of **mobile apps** on smartphones and tablets.
- The emergence of skills gaps among various sectors may impact the ability of workers to transition.

1.2.2 The Impact of Instructional Technologies on Apprentice Learning:

These instructional technologies are relevant to a range of trades and are impacting the way apprentices learn during the technical or 'at-school' portion of their training. Across the diverse systems of apprenticeship training, examples of all of these instructional technologies can be found. The most transformative of these technologies and also the costliest to adopt are likely to be simulation technology and online learning. Some interviewees did talk about student response systems or 'clickers,' but the benefits for apprentice learners were limited and, therefore, have not been included in this discussion.

- **3-D Software Applications:** The growing sophistication of 3-D applications has occurred in tandem with the growth of animation technology. There are three common uses of 3-D applications in apprenticeship training: (a) to depict objects for the machining and mould-making trades that will be created in three dimensions, (b) to represent the components of mechanical systems and (c) to link two-dimensional drawings to three-dimensional structures so that students in construction trades understand how different perspectives (elevation, plan, plot, section, detail, etc.) relate to the total structure.
- **Simulation Technology:** Simulation technology is currently being used to develop skills in welding, vehicle operation, heavy equipment operation and spray-painting. Simulation technology is not the same as a 3-D software application. Simulation technology is an immersive learning experience that replicates the actual physical tasks associated with a skill. Simulation technology has a number of advantages including safety, lower operating costs than actual equipment, and the ability to detect and correct errors before they become embedded habits.
- **Streamed Video:** Colleges and training centres are using both YouTube and server-hosted catalogues of video to augment instruction.
- **Social Media:** Many courses use Facebook, Wikis, and other social media to support instruction.
- **Online Learning:** Online learning is among the most transformative of instructional technologies. It holds out the prospect of significantly lowering costs for governments and apprentices, and decreasing disruption of the workplace for employers. There is no policy framework for implementing online learning. There is no consensus in the apprenticeship community on the role of online learning. Some stakeholders regard online technology as having little application to apprenticeship, which is focused on hands-on, practical learning. Others see a significant role for online learning, but favour models that incorporate instructor support. In the absence of external financial support for development costs, many colleges and training centres will find only a weak business case for extending the online model to apprenticeship training.
- **Learning Management Systems:** Learning Management Systems (LMS) are software applications that manage most administrative aspects of training delivery including registration, student record keeping, instructor management, resources and course design for an e-learning environment. LMS applications both encourage experimentation with online delivery and substantially reduce the costs of developing online courses. LMS applications have been installed in virtually every college. There are examples of their use in industry-based training centres, but they are less common in that environment.
- **Use of the Web as a Resource:** Instructors are providing course materials on the web or directing students to technical resources such as codes or standards and manufacturers' specification sheets and manuals. Assignments often require students to locate resources on the web.

- **Mobile Applications (Apps):** Mobile apps are available to perform common calculations for many trades and to provide other technical resources. A scan of iTunes turns up hundreds of apps that are relevant to the construction and motive power trades. Instructors report that many apprentices use these apps. There is considerable variance in how colleges and training centres have responded to the 'app phenomenon.' Some incorporate the use of apps into courses. Others do not permit their use.

1.2.3 The Impacts of E-Learning On-the-job:

E-learning is impacting training at the workplace in a number of ways:

- **Vendor-supplied training:** There has been an increase in vendor-supplied training, much of which is provided in e-learning formats.
- **Corporate Universities:** The use of corporate universities is one of the most important trends in private sector human resources development among global companies. Many corporate universities focus on training managerial and engineering staff. However, there are also examples of corporate universities that design and deliver training for the maintenance trades.
- **Industry Associations as Suppliers of E-Learning Products:** Industry associations are increasingly suppliers of skills training in an e-learning format. This trend has been especially important in making e-learning products accessible to small and medium-sized enterprises. While Canadian industry associations are not heavily engaged at this time in the delivery of skills training, many U.S.-based industry associations have moved in this direction. In many industries, it is common for Canadian companies to belong to U.S.-based industry associations to access their technical and training resources. U.S.-based associations may not be familiar with Red Seal standards.
- **Online Log Books:** Most apprenticeship administration authorities track on-the-job experience through a traditional log book that is completed by an apprentice and signed by a supervisor or journeyperson. Experimentation with online log books has only begun in Canada. In Australia, online log books are used more extensively to track hours and experience.
- **Online Technical Resources:** Technical glossaries, codes, standards and product catalogues are available online and employees, including apprentices, are expected to find these sources using the web.

1.3 Conclusion:

Technology is having an impact on apprenticeship training both on-the-job and during technical training. In the some trades, apprentices will need more advanced skills in order to keep up with emerging technologies and more sophisticated pieces of equipment. Employers' increased use of vendor training and U.S. industry association training resources are trends that could pose a challenge for apprenticeship systems that seek to maintain Red Seal standards since trainers in other countries may not be familiar with or subject to these standards. 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. Apprentices may be asked to use online log books as well to track their hours and skills acquisition. Online learning has skills implications in terms of motivation and time management and apprentices who struggle in these areas will need supports on an ongoing basis if they are to do online learning.

2.0 Introduction and Methodology

2.1 Introduction

Technology is having a significant impact on apprenticeship both on-the-job and during technical training. Given the importance and urgency around these developments, as a part of CAF-FCA's 2011-14 Strategic Plan, a new priority emerged on the subject of "Technology and Innovation." Based on a literature review of national and international sources and 51 interviews with employers, employer associations, college instructors and trainers, this research report identifies key trends in three main areas: industry trends impacting trades and skills requirements, the use and impacts of instructional technologies, and the impacts of e-learning on-the-job. Training will demand apprentices have more theoretical knowledge and higher levels of computer literacy and digital skills than in the past. Apprentices may be asked to deal with more complex systems and equipment, to learn online, to find codes and regulations using the web, to use smartphones, apps, and tablets, and to track their hours and skills acquisition using e-management systems. Maintaining Red Seal training standards may be challenging if vendor and U.S. trainers do not understand the requirements. Broader engagement with e-learning and e-management, developing reliable screening criteria for e-learning readiness, addressing the training needs of more technology-intensive employers and documenting innovative practices are all suggested ways the apprenticeship community may address the challenges that lie ahead.

2.2 Methodology

This study is based on a literature review and 51 interviews with apprenticeship stakeholders. The literature review examined published research, reports commissioned by governments and other public agencies, and industry publications. The principal sources were from Canada, the U.S., Australia and the United Kingdom. Employers, industry association representatives, instructors and training centre administrators were all interviewed as a part of this project. Figure 1 summarizes the distribution of the interviews by stakeholder category.

Figure 1: ***Distribution of Interviews across Stakeholder Groups***

Stakeholder Group	Number
Colleges, CEGEPs[1]	28
Private Trainers	1
Union / Industry Training Centres	4
Employers / Employer Associations	11
Agencies / Community Organizations, etc.[2]	7
Total	51

The majority of the interviews were conducted with training deliverers as the stakeholders with the most direct involvement with new instructional technologies. Interviews with employers and employer associations were particularly helpful in identifying overarching trends in technology and the increased importance of e-learning as a preferred mode of training delivery for many employers.

Most of the interviews were conducted with stakeholders from Western and Central Canada. Figure 2 summarizes the geographic distribution of the interviews:

Figure 2: ***Geographic Distribution of Interviews***

Region	Number
Western Canada	22
Central Canada	22
Atlantic Canada	5
Outside Canada	2
Total	51

The report is organized into three themes: industry trends impacting trades and skills requirements, the use and impacts of instructional technologies, and the impacts of e-learning on-the-job. The order in which the themes are discussed reflects their order of importance based on the research findings.

- **Chapter 3** of this report describes trends that broadly cut across a range of industries and trades. These trends affect either the skills that apprentices need to acquire or how apprentices learn their trade skills.
- **Chapter 4** discusses instructional technologies that are altering how training is delivered in a classroom or training centre environment. The chapter also examines trends in e-learning, including instruction delivered online.
- **Chapter 5** outlines trends in workplace learning.
- **Chapter 6** summarizes the main findings of the report.
- **Chapter 7** offers suggestions for addressing the challenges ahead.

1 Collège d'enseignement général et professionnel. These are public post-secondary education institutions exclusive to the education system in Quebec.

2 This stakeholder group included: Aboriginal organizations (2), safety associations (1), literacy organizations (1), and planning agencies with responsibility for apprenticeship (3).

3.0 Industry Trends

> "Our greatest difficulty is keeping up with changes in technology... We run off provincial course outlines that more often than not lag industry developments."
>
> Chair,
> Construction Program

The focus of this chapter is on industry trends that impact skill requirements and training. These trends are evident in a range of sectors and trades. Technology is definitely impacting the nature of the work tradespeople do and is demanding a higher level of skill and more advanced computer literacy than in the past. Technology is also impacting the ways on-the-job training is provided to tradespeople, especially in the manufacturing sector where there is a greater focus on e-learning and vendor training. Some employers in the manufacturing, resource-based and utilities sectors doubt whether workers in the construction sector are developing the skills that they will require in the future, possibly impacting the ability of those workers to transition. Some employers are also questioning whether apprenticeship training can remain relevant given their unique needs.

3.1 Acceleration of the Pace of Technological Innovation

Across virtually all trades and all apprenticeship stakeholder categories, there is a perception that the adoption of new technology has accelerated in recent years. In equipment-intensive trades, the focus is on the incorporation of electronic controls and sensors into the machinery and equipment used to get a job done. In the electrical and mechanical trades, the emphasis is on the electronic components that tradespersons must know how to troubleshoot and repair. In the traditional construction trades, new building materials have been introduced alongside new types of equipment. Technical drawings are increasingly electronic and will soon transition into 3-D applications as Building Information Modelling (BIM) becomes the new industry standard. Coupled with this perception of an accelerating pace of technological innovation is a sense that trade standards and apprenticeship curricula often lag behind leading industry practices.

There is considerable unevenness across the economy in the pace and extent to which the trends described in this chapter are reflected in workplaces. Some industries lead others. Within industries, some companies are early adopters of new technologies, while others are more cautious. Notwithstanding this diversity, there do appear to be some trends which will have implications for the apprenticeship systems in Canada. Many companies in the manufacturing sector, the resource industries and utilities sector have invested significantly in new machinery and equipment. In individual workplaces, this leads to changes that are more significant than may be suggested by industry-wide data. Historically, the aforementioned sectors have often recruited journeypersons who received their apprenticeship training in the construction industry. For the most part, the skills acquired by apprentices in the construction industry were portable to these other sectors. The interviews conducted for this report suggest that a skills gap is emerging among various sectors and cross-sectoral hiring may become less likely.

3.2 Incorporation of Information and Communications Technologies (ICTs) into Machinery and Equipment

Among the most important trends is the incorporation of information and communications technologies into machinery and equipment.[3] There is:

- the increased use of sensor-based diagnostic equipment for identifying problems in manufacturing and processing systems as well as in vehicles,
- more widespread adoption of complex systems of automation in manufacturing and resource extraction, including robotic technologies that have a learning capability,
- increased prevalence of onboard electronic control systems in vehicles and also in mobile machinery and equipment,
- greater use of 3-D visualization systems, and
- increased reliance on technical documents that are available only in electronic format and usually disseminated over the web.

3 Terwiesch, Peter and Christopher Ganz, "Trends in Automation" in Nof, Shimon, ed., *Springer Handbook of Automation*, Springer, 2009.

Guizzo, Erico and Travis Deyle "Robotics Trends for 2012", *Robotics & Automation Magazine*, IEEE (March 2012).

Sauter, T., "The Evolution of Factory and Building Automation", *Industrial Electronics Magazine*, IEEE, vol. 5, issue 3 (September 2011).

"For industrial electricians, millwrights, refrigeration and air conditioning mechanics, and motor systems technicians, we only hire persons into apprenticeships after they have completed 2-3 years of college training as a technician or technologist."

Human Resources Advisor, Major Manufacturer

"In automotive technology there is blurring between the trades and technicians."

Chair, Transportation Technology Program

One commentator characterized ICT-driven technological change as "smart everything."[4] In a similar vein, an article in IEEE[5]'s Spectrum magazine commented that, "It takes dozens of microprocessors running 100 million lines of code to get a premium car out of the driveway, and this software is only going to get more complex."[6]

In some industries, the application of ICTs to machinery and equipment is blurring the distinction between mechanical, hydraulic and electronic systems. This has led to a re-thinking of how trades that maintain these systems should be defined. The term 'mechatronics' has been coined to reflect the merging of skills that were previously associated with distinct trades, but which are being combined and reshaped by ICTs.[7]

Interviews with employers and with apprenticeship instructors indicated a widespread perception that both the pace and breadth of ICT-driven change have accelerated in the past five years.[8]

4 Presentation by Norman Dziedzic, "New Trends in Automation". CMA/Flodyne/Hydradyne (June 16, 2010). Available at: http://www.slideshare.net/CMAFH/new-trendsautomation#btnNext

5 IEEE stands for the Institute of Electrical and Electronics Engineers.

6 Charette, Robert N., "This Car Runs on Code". *IEEE Spectrum* (February 2009). Available at: http://spectrum.ieee.org/green-tech/advanced-cars/this-car-runs-on-code/0 .Accessed November 2012.

7 Müller, Dieter and J. M. Martins Ferreira, "MARVEL: A Mixed Reality Learning Environment for Vocational Training in Mechatronics, Research Center ARTEC - Bremen University". In P. Grew and G. Valle, (eds). *Proceedings: International Conference on Technology-enhanced Learning*. Milano, Italy (2003).

8 This perception is supported by data on the sale of ARM microprocessors, which are among the most commonly used chips for embedding ICT into another device. It took Intel 30 years to ship its first 1.0 billion microprocessors and four years to ship its second 1.0 billion. In 2011, ARM shipped (or licensed) 7.9 billion microprocessors. This compares with 2.8 billion in 2009.

3.3 Increased Importance of Technology Training

In many segments of the manufacturing sector, production processes have become more complex. This change is the result of the incorporation of information and communications technologies into machinery and equipment. An important implication of this trend is that maintenance and trouble-shooting in many manufacturing settings often requires an understanding of computer interfaces and electronic control systems as well as traditional trade skills. Some stakeholders interpret this as a blurring of the functional boundary between technicians/technologists and skilled tradespersons. Others interpret the trend as increasing the amount of theoretical knowledge that a journeyperson needs when maintaining machinery and equipment that uses advanced manufacturing technologies. Regardless of whether emphasis is put on the tasks or on required knowledge, the traditional boundary between technicians/technologists and skilled tradespersons is no longer clearly defined.

A similar overlapping of technology skills with trade skills is evident in motor vehicle maintenance and repair. Vehicles increasingly use on-board electronic control systems and service bays use sensor-based diagnostic systems to detect malfunctioning components.

Although technology skills and trade skills are crossing over into each other's territories, as evidenced in many workplaces, it would be erroneous to interpret the trend as a universal phenomenon. In many sectors of the economy, the distinction between technicians/technologists and skilled tradespersons continues to operate much as it did in the past. In these workplaces, employers continue to attach primary importance to the practical skills and the dexterity skills of tradespersons, and they expect the apprenticeship systems to focus on these skills rather than on theoretical skills. In other workplaces, the need for increased theoretical knowledge in the skilled trades is a moderate requirement that does not alter the fundamental distinction between skilled tradespersons and technicians/technologists.

"There is no blurring of the line. Under no circumstances will a cement mason ever calculate slump, percent of air entrainment, or compressive strength or check fly ash content under a microscope. Nor will a technician ever pour concrete."

Aboriginal Apprenticeship Administrator

3.4 Increased Importance of Vendor Training

Vendor training has taken on more importance. The *World Intellectual Property Report, 2011* describes the strong relationship between knowledge-based economic growth and patent activity.[9] Data in the report points to a doubling of patent activity after 1995. A consequence of this is that proprietary technologies have become more important and, as a result, the role of vendor-supplied training has also increased in importance. Interviews with industry-based training centres and colleges indicate that vendor training is especially important, though not limited to, the motive power trades and the equipment-intensive trades. For example, some colleges offer training that is geared to a particular manufacturer's platform.[10] In the construction trades, innovations in building materials are often as important as innovations in machinery and equipment.

The increased importance of proprietary technologies and vendor-supplied training resources poses a challenge for apprenticeship training systems. Typically, apprenticeship training, whether delivered by colleges or by industry training centres, avoids a strong association with a particular vendor's technology. There is the view that apprenticeship training should be generic, portable and widely applicable rather than focused on one employer's needs. In some circumstances, however, remaining relevant to employers may require a more formal recognition within the apprenticeship model of the importance of proprietary technologies and vendor-supplied training resources.

9 World Intellectual Property Organization, *World Intellectual Property Report, 2011: The Changing Face of Innovation.* (2011).

10 Centennial College in Toronto, Ontario delivers programs for 'Automotive Service Technician Toyota' and 'Automotive Service Technician Honda'. They are described as modified apprenticeship programs.

3.5 E-learning as the Preferred Mode for Training

In 2009, the Canadian Council on Learning lamented that "levels of adoption of e-learning have been slower than anticipated."[11] Since then, there is growing evidence that the pace of e-learning adoption has increased significantly. Three trends, in particular, have made employers adopt a more positive attitude towards e-learning solutions for their training needs. First, a wide range of course authoring applications are now available. These applications reduce the up-front design costs. Second, there has been an exponential growth in the number of firms offering course development services and they are designing better quality learning products.[12] Finally, the early adopters have worked out the glitches. E-learning is now widely seen as a best practice and is actively promoted by many industry associations. For all of these reasons, in a growing number of industries, e-learning has become the preferred mode for delivering training.[13]

The trend to adopt e-learning is especially evident in the U.S. A survey of 100 large companies with an average of 8,400+ employees indicated that 41per cent of the companies currently have an e-learning portal. Virtually all of the remaining survey participants indicated that they are either developing an e-learning strategy or intend to do so.[14]

11 Canadian Council on Learning, *State of E-learning in Canada.* (May 2009). See page 7.

12 In 2002, companies focused on the design and delivery of e-learning products to industry-established the Canadian e-learning Enterprise Alliance. The Alliance currently lists 370 suppliers. A 2001 report profiles the industry in Ontario: Interactive Ontario, *e-learning Industry Snapshot*, 2010 (January 2011).

13 The rapid uptake of e-learning in industry is described in: Donohue, David A.T. and Timothy D.A. Donohue and Jared M. Kapela, "The Rapid Growth of e-Learning in the Upstream Petroleum Industry". Paper presented to 2011 Society of Petroleum Engineers Annual Technical Conference (Denver, Colorado 2011).

14 DDI HR Benchmark Group, *State of Development of E-Learning* (2002).

3.6 Mobile Apps

The use of smartphones and tablets is increasingly common in industry. Employers report using smartphones to upload job information and to download technical specifications. Apps are also commonly used to perform technical calculations. Many suppliers provide apps to facilitate accessing technical information on products. GPS applications are used to track shipments and service vehicles as well as to navigate destinations.

4.0 Instructional Technologies

> "We piloted online training for auto service technicians. This allows students to check electrical systems, steering, brakes, transmissions, and fuel systems online before they work on an actual car. We are hopeful that this will save money on tools and equipment. If they first practice online, they are less likely to burn the equipment."
>
> **Auto Technician Instructor**

The focus of this chapter is on the use of instructional technologies that are used during technical training or when apprentices are at school. The advantages and disadvantages of the instructional technologies, including online learning, are outlined. Examples of Canadian initiatives are provided. Across the diverse trades and systems of apprenticeship training, examples of these instructional technologies can be found. The most transformative of these technologies and the costliest to adopt are likely to be simulation technology and online learning. According to the interviewees, 3-D software applications and simulation technologies are enhancing apprentice learning and the ability of apprentices to practice their skills in a safe environment. Some instructors report that apprentices learn dexterity skills required for their trade faster when using simulation technology. Online learning has advantages because it allows apprentices to learn at their own pace and helps reduce the costs of training. Other forms of instructional technologies are also helping apprentices learn, particularly if they have the computer literacy and digital skills to take advantage of them. These various technologies do not, however, replace real experience on the job site or the value of instructor-supported learning. Apprentices, by nature, are 'hands-on' learners and most may continue to prefer the traditional in-school learning environment. In addition, the report finds that no policy framework, prohibitive costs and copyright issues may pose barriers to the further expansion of online learning in Canada.

4.1 3-D Software Applications

Three-dimensional software applications create an object in two-dimensional space which has the appearance of three dimensions. The object can be rotated in all directions so that it can be viewed from different angles. Complex objects can be layered so that different layers can be removed to reveal the interior of the object. The object can also be resized to highlight particular features. Three-dimensional software applications are computationally intensive. As a result, until approximately ten years ago, these applications could only be run on specialized workstations. However, as the computation power of mainstream microprocessors increased, 3-D applications became generally more accessible. The gaming industry, in particular, has been a driving force in the extension of increased computation power into mainstream microprocessors. The growing sophistication of 3-D applications has occurred in tandem with the growth of animation technology.

There are three common uses of 3-D applications in apprenticeship training. The first, and probably original use, is to support training in the machining and mould-making trades. This development was a natural step when two-dimensional CAD applications were augmented by applications that offered 3-D depictions. The second common use of 3-D applications is to represent mechanical systems. Three-dimensional depictions enable a student to visualize how the different components of a mechanical system operate. In some cases, this technology can also be combined with animation to show the depicted system in operation. This use of 3-D applications is particularly relevant to training in the motive power trades and the millwright trade. Three-dimensional applications also support training in the electrical, pipe, and sheet metal trades. In the construction trades, 3-D applications are used to link two-dimensional drawings to three-dimensional structures so that students understand how the different perspectives (elevation, plan, plot, section, detail, etc.) relate to the total structure.

> **"3-D really helps with understanding theory."**
>
> **Construction Trades Instructor**

Three-dimensional software applications cannot substitute for working with real equipment and a combined approach is best. A European study examined and compared instruction in the operation and maintenance of pneumatic manufacturing equipment using 3-D software only, using 3-D software in combination with hands-on experience, and using only hands-on training. The combined use of 3-D software application with hands-on experience was deemed the most effective approach.[15]

The use of 3-D software applications is widespread in apprenticeship training in both the college system and in industry-based training centres. One article describes how the British Columbia (B.C.) Institute of Technology has used 3-D applications "to train aircraft mechanics how to make fewer errors, [train] mechanics how to disassemble, assemble, and inspect aircraft engines, [train] carpenters how to build roofs, [and train] plumbers how to troubleshoot hot water heating systems... test and troubleshoot backflow prevention systems... adjust the air/gas mixtures in furnaces, [and train] fish canners how to identify flaws in cans..."[16]

15 Schmudlach, Kai and Eva Hornecker, Hauke Ernst and F. Wilhelm Bruns, "Bridging Reality and Virtuality in Vocational Training". CHI '00 Extended Abstracts on Human Factors in Computing Systems (2000).

16 Fenrich, P.J., "Effective Vocational Computer-Based Training". British Columbia Institute of Technology, unpub. ms. undated (c. 2006).

4.2 Simulation Technology

Both colleges and industry-based training centres in Canada are investing heavily in simulation technology. This technology is being applied to training in a broader range of trades. The use of simulation technology, often in conjunction with 3-D software applications, is one of the most significant innovations in apprenticeship training.

Simulation technology is currently being used to develop skills in welding, vehicle operation, heavy equipment operation and spray-painting. Simulation technology is not the same as a 3-D software application. A 3-D software application only allows a learner to interact with an object through a keyboard or mouse. Simulation technology, by contrast, is an immersive learning experience that replicates the actual physical tasks associated with a skill. In this way, simulation technology develops both technical skills and dexterity skills. A student interacts with the simulated machinery or equipment in the same way that he or she would interact with the actual machinery or equipment. Historically, the high cost of simulation technology limited its application to a narrow range of situations. Flight simulator systems for training pilots are one of the longest standing applications of simulator technology.

"You put the helmet on, pick up the torch and you feel like you're welding."

College Welding Instructor

Figure 3:
Okanagan College - Welding Simulator

Over the past decade, the sharp decline in computing costs has reduced the cost of creating simulation systems. Among the earliest applications of simulation technology was for instruction in welding. Welding was also one of the earliest applications of robotic technology. The development of robotic technology faced two challenges, which are similar to those faced in developing simulation technology: how to capture and reproduce the movements of experienced welders and how to use sensors to guide the welding process. Colleges that have used simulation technology to support instruction in welding report positive outcomes. First, simulation technology eliminates the need for consumables. Second, simulation technology eliminates most of the safety concerns. Thirdly, simulation systems detect and correct student errors more efficiently than an instructor. Instructors report that, on average, students develop proficiency and acquire welding dexterity skills faster when using simulation systems than when learning on actual equipment. Similar reports are offered by instructors in gas technician training and spray painting. Simulation technology is also used to train operators of heavy vehicles on how to use air brakes.

The Operating Engineers Training Institute of Ontario (OETIO) was the first training centre in the world to use a simulator to teach crane operation. OETIO is now using its second generation of simulator for training in crane operation. OETIO also uses a variety of simulators to replicate equipment such as excavators. The 'Mini-X,' for example, is a scaled down version of a mechanical excavator that looks and operates like an actual excavator. The 'Mini-X' controls can be interchanged between both Caterpillar and John Deere control configurations, which are the largest equipment suppliers in North America. Other training centres operated by the International Union of Operating Engineers also use simulators. Figure 4 shows the excavator simulator used by the Operating Engineers Training Institute of Manitoba.

Figure 4:
Operating Engineers Training Institute of Manitoba Excavation Simulator

It is important to stress that 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. Simulation technology does, however, offer the following advantages:

- Although costly, simulators are sometimes less expensive than actual equipment.
- Simulators do not consume energy, fuel and materials to the same degree as the actual equipment. This reality reduces operating costs.
- Simulators are safer. This is especially important for early stage learners.
- Simulators detect and correct errors before they become embedded habits.
- Dexterity skills and proficiency are acquired at least as efficiently using simulator technology and possibly acquired even more quickly.
- The level of complexity can be altered using a simulator so that tasks become progressively more challenging.

In some jurisdictions, there is significant industry or government support for the increased use of simulation technology in apprenticeship training. In Australia, for example, the Civil Contractors Federation has recommended giving simulation technology a central role in apprenticeship training.[17] In the European Union, the Leonardo Da Vinci Program has supported research into new applications of simulation technology in vocational training.

Interviews with apprenticeship instructors indicated that there is not universal agreement among apprenticeship instructors on the merits of simulation technology. Some instructors believe that any teaching strategy that departs from using actual machinery and equipment weakens the practical orientation of apprenticeship training. 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. An Australian study found that "an important step in successfully embedding the use of Virtual World technology... was to provide suitable professional development for teachers with the view of enhancing creative pedagogical thinking."[18] Instructors were also engaged in the design of the virtual environments and the features of the simulation technology.[19]

> **"Virtual reality systems are very much part of how we train. They are used for the painting trade, glazing, and for sign and display. Virtual reality technologies have also been developed for the drywaller and taper trades. There is also a virtual reality simulator for sandblasting. All of these systems strengthen hand-eye coordination and improve techniques before they are applied to an actual product."**
>
> **Administrator,**
> **Industry Training Centre**

17 Civil Contractors Federation (Australia), Policy Document - Civil Contractors Federation Submission to Skills Australia "Creating a Future Direction for Australian Vocational Education and Training - a Discussion Paper". (December 2010).

18 Lewis, Sian and Brad Beach, "E-Learnings from Vocational Education in Victoria: Investment and Innovation to Better Support Industry and Learner Needs". Undated paper (c. 2010).

19 Ibid.

> **"We did try to introduce simulation for basic electricity and motors and control and could not get the buy-in from the apprenticeship faculty."**
>
> **College Apprenticeship Administrator**

Notwithstanding the reservations of some instructors, the adoption of simulation technology is among the most important innovation trends in apprenticeship training. This trend will have implications for instructor professional development, capital costs associated with apprenticeship training and the relationships between training deliverers and the developers of simulation technology. Although there are notable Canadian suppliers (e.g., CMLabs, 123Certification.com), most simulation technology is being developed outside of Canada.

4.3 Streamed Video

Some instructors report that they refer students to YouTube videos. Others maintain a catalogue of videos that can be streamed to a student's computer. Some instructors report that they have produced training videos, which they host either on their college server or on YouTube. An important advantage of YouTube is that it allows for the sharing of resources by training centres that are delivering training for the same trade. By contrast, hosting video resources on a password-protected server restricts access.

4.4 Social Media

Some instructors report using social media resources, though their application does not appear to be widespread:

- Facebook provides an opportunity to create an electronic group where experiences can be shared. This web-based connection is potentially valuable in countering the isolation of online learning.
- Posting videos on YouTube that feature student projects can provide inspiration to other students.
- 'Wikis' enable instructors to compile course resources so that they can be referenced and updated.
- Pinterest and other photo-sharing websites such as Flickr or Picasa allow for photographs to be exchanged.
- Slideshare allows for the sharing of PowerPoint presentations.

4.5 Online Learning

Another important technological development impacting apprentice learning is e-learning or online learning. The term e-learning encompasses both online learning, which is delivered remotely, and computer-based learning, which may be delivered in a school or a training centre. It is common to use the terms e-learning and online learning interchangeably. The opportunities and challenges associated with online learning as it relates to apprenticeship training and an overview of some apprenticeship-focused online learning initiatives in Canada are provided below.

4.5.1 Online Learning Models

The literature about online learning identifies five models or approaches to the delivery of training:[20]

1. **Recorded Classroom Presentations:** These courses are video recordings of classroom presentations.

2. **Stand-Alone Online Delivery:** These types of courses consist of structured learning materials that are available on demand. No instructor support is provided. More sophisticated courses have interactive modules that engage students, sophisticated 3-D depictions, animations and streamed video. These courses typically include tests so that a student can evaluate his or her progress.

3. **Instructor-Supported Online Delivery:** These types of courses are essentially the same as stand-alone courses except that students can email an instructor for support. Providing instructor support requires scheduling, hence the availability of these courses is sometimes limited.

4. **Online Delivery with e-Collaboration:** These types of courses include scheduled periods of live chat or video chat with instructors and other course members. This type of course is uncommon since it requires students to have a web camera ('cam') and audio peripherals as well as sufficient bandwidth.

5. **Hybrid Courses:** These courses combine online delivery with in-school training. Typically the theory portion of training is covered by the online training while the in-school training focuses on the lab or shop.

20 Hartwig, Bradley D., "e-Apprenticeship: Establishing Viability of Modern Technology in Traditional Practice". *Journal of Instructional Science and Technology* (e-JIST). Volume 10, issue 1, October 2007.

Booth, Robin; Clayton, Berwyn; Hartcher, Robert; Hungar, Susan; Hyde, Patricia; and Wilson, Penny. "The Development of Quality On-line Assessment in Vocational Education and Training", National Centre for Vocational Education Research (NCVER). Volume 1 [and] Volume 2, Australia, 2003.

Brennan, R., Horton, C., McNickle, C., Osborne, J., and Scholten, K., *On-line learning on location: Perspectives from regional Australia*. Leabrook, South Australia: Australian National Training Authority. 2003.

Brennan, R, McFadden, M and Law, E., *All that glitters is not gold: on-line delivery of education and training, Review of research*. Australian National Training Authority, NCVER, Adelaide, Australia, 2001.

Cashion, Joan and Phoebe Palmieri, "The secret is the teacher: The learner's view of on-line learning," NCVER, Australia, 2002.

Curtain, Richard, "On-line Delivery in the Vocational Education and Training Sector: Improving Cost Effectiveness [and] Case Studies", NCVER, Australia, 2002.

Eklund, John; Kay, Margaret; Lynch, Helen M., "E-learning: emerging issues and key trends: a discussion paper", NCVER, Australia, 2003.

EU Commission, DG Education and Culture. *The use of ICT for learning and teaching in initial Vocational Education and Training*, 2005.

Fenrich, P.J., "Effective Vocational Computer-Based Training". British Columbia Institute of Technology, unpub. Ms. Undated (c. 2003).

Harper, B., Hedberg, J., Bennet, S., & Lockyer, L., *The on-line experience: the state of Australian on-line education and training*, NCVER, Adelaide, Australia, 2000.

Lewis, Sian and Brad Beach, "E-Learning Learnings from Vocational Education in Victoria, Australia: Investment and innovation to better support industry and learner needs" unpub ms., 2010.

Moran, Louise and Greville Rumble (eds.), *Vocational Education and Training Through Open And Distance Learning*, Commonwealth of Learning and RoutledgeFalmer Press, 2004.

4.5.2 Canvass of Canadian Jurisdictions:

In most Canadian provinces and territories, there are policy initiatives to increase the role of online learning in the education system, but few of these initiatives involve apprenticeship training. In contrast, the federal government in Australia has published *The National VET E-Learning Strategy, 2012-2015*. The strategy lays out a comprehensive path for investing in e-learning and making e-learning one of the major channels for delivering vocational education and training.[21] In the United Kingdom, there is also a strong policy imperative to leverage online training to meet apprenticeship training needs. There are a number of private developers that design e-learning products for apprenticeship training in the United Kingdom.

In Canada, colleges and provincial apprenticeship authorities have instituted e-learning options or commenced pilot projects. The list below is not comprehensive, but gives examples of the types of initiatives that have been undertaken:[22]

British Columbia:

E-PPRENTICE is an initiative of B.C.'s Industry Training Authority (ITA). Currently E-PPRENTICE offers technical training for the automotive service technician and automotive collision repair trades through the Vancouver Community College. Professional cook Level 1 is offered through Camosun College. Welder Level C is offered through the Piping Industry Apprenticeship Board.

Alberta:

The Southern Alberta Institute of Technology (SAIT) commenced a pilot project to ascertain the efficacy of e-learning. The piloted trade was automotive service technician.[23] The pilot project was a 'blended model' that combined e-learning with in-school exposure to practical applications. This model was advantageous for the apprentices who had to take less time off work and could keep earning wages while still completing their technical training requirements. An evaluation of learning results indicated that students performed at least as well in the 'blended model' e-learning environment as in the traditional in-school model of training. The 'blended model' was then extended to the welding, plumbing and electrical trades. In the 'blended model', students take the theory components of their in-school training online and the lab or workshop courses at SAIT. The online material uses 3-D software applications and animation extensively. Examinations are also incorporated into the online courses. The online course material is available on demand. Students can cover the material at the pace that is most suited to their circumstances. Instructor support is available via email. Alternatively, students can ask for assistance when they attend labs.[24] SAIT's 'blended model' delivers roughly 80 per cent of intermediate and advanced instruction online and approximately 20 per cent of training in a hands-on shop setting.

The Northern Alberta Institute of Technology (NAIT) delivers online training for apprentices in the electrical trade and power engineering. In 2006, NAIT experimented with video-conferencing to deliver apprenticeship training in the welding and electrical trades. Of the 65 students who participated,

21 Australia, Department of Industry, Innovation, Science, Research and Tertiary Education, *The National VET E-Learning Strategy, 2012-2015*. Australia's apprenticeship system is particularly robust. An international study estimates that in 2008-09, Australia had 39 apprentices per 1,000 persons employed. This is roughly double the rate in Canada. For international comparisons, see: Steedman, Hilary, "The State of Apprenticeship in 2010: International Comparisons - Australia, Austria, England, France, Germany, Ireland, Sweden, Switzerland". Report for the Apprenticeship Ambassadors Network. London School of Economics and Political Science - Centre for Economic Performance (2010).

22 Prince Edward Island, New Brunswick, Northwest Territories, Yukon and Nunavut, were not listed. To the author's knowledge, these jurisdictions do not have e-learning options available for apprentices at this time. Quebec was not mentioned due to the fact any online learning initiative would take place before the individual officially becomes an apprentice since technical training occurs first in the Quebec system.

23 The pilot project is described in: Schatz, Darwin, "Final Report: Blended Learning for Apprentices" undated mss. (c 2009).

24 The 'blended model' is described in a YouTube video: http://www.youtube.com/watch?v=KaPttvF774A .

Additional information is provided in: SAIT - Apprenticeship Blended Learning Programs: http://www.sait.ca/programs-and-courses/apprenticeships-and-trades/apprenticeships/additional-information/apprenticeship-blended-learning-programs.php; Shewchuk. Lionel, "Delivering Apprenticeship Training in a Blended On-Line Learning Environment". Presentation at CAF-FCA 2012 Conference (June 5, 2012).; and Burkle, Martha, "Designing E-learning in Virtual Worlds for Apprenticeship Students in Canada". Paper presented at International Conference on E-Learning (ICEL), (New York, New York, U.S.A., June 9-11, 2010).

39 completed their training successfully, while 25 withdrew and 1 student did not pass the examination.[25] Currently, NAIT does not deliver any online apprenticeship training, although it does deliver a range of other courses online outside of its apprenticeship programs.

Saskatchewan:

The Saskatchewan Apprenticeship and Trade Certification Commission (SATCC) delivers a common math training course online.

Manitoba:

In 2011, Manitoba launched the E-Apprenticeship Design and Development Initiative (EADDI), following the evaluation of a pilot project focused on training apprentice electricians. Through EADDI, online training is available for 12 trades and common core subjects. The Manitoba government also indicated that offerings would be expanded to other trades in 2013.

Ontario:

In a recent report by Colleges Ontario, they recommend the expansion of e-learning training options for apprentices.[26]

Through a joint initiative, Durham College and Sault College offer a hybrid model for industrial mechanics/millwrights. The three levels of the theory portion of the in-school training are taken online. The online course is supplied by Durham College. The shop training portion of the in-school training is offered by Sault College. The hybrid program is geared to apprentices in remote areas of Northern Ontario as it reduces the amount of time they must spend in residence at Sault College. Apprentices usually study the theory in face-to-face classroom settings one day a week over 35 weeks or in a more compressed 8 to 10 week block of time. The online training is self-paced. The online course is also available to students at Durham College.

Additionally, Durham College has partnered with the Construction Millwrights Union Local 2309 to provide hybrid learning for their members with online theory and weekly practical training at Durham College. In return, the Union has supplied the College with equipment that can be used in a variety of programs.

Nova Scotia:

Nova Scotia Community College (NSCC) offers online training through its Virtual Campus for automotive service technician, electrician, cook, gas fitter, power engineer and refrigeration plant operator. Courses use web-based content, streamed videos, interactive tutorials and video conferencing. Students have three months to complete a course.

Newfoundland and Labrador:

The College of the North Atlantic (CNA) recently piloted an online course at the advanced level for the electrician trade. CNA is considering expanding its online offerings for apprenticeship training.

Industry-based training centres in Canada have not, as yet, commenced offering online apprenticeship courses. Union members in some construction trades do, however, have access to online training resources developed by international unions. For example, the International Union of Painters and Allied Trades provides online training in a number of skill areas, although much of this training pertains to upgrading rather than apprenticeship training.

25 Shaw, W.A. and Eleanor Frandsen, "NAIT D.A.T.E. (Distance Apprenticeship Training and Education) and Beyond: Effective Approaches to Democratize the Acquisition of Proficiency and Aptitude in Vocational Training", unpub mss., undated (c. 2009).

26 Colleges Ontario, *Transforming Ontario's Apprenticeship Training System.* July 2009

4.5.3 Instructor Experience with Online Learning:

Instructors who had experience with online learning delivery made the following observations during interviews:

- The performance of apprentices, based on test scores and completion rates, is at least on par with traditional in-school training. Self-motivated apprentices who already have good grades may be electing to enrol in online courses, partially accounting for the positive results.
- When surveyed, apprentices describe themselves as satisfied with the online learning experience. The high rates of satisfaction could stem from the fact that apprentices with no affinity for online learning are not enrolling in the courses.
- Apprentices with prior education such as a university degree perform better in an online environment than students with lower educational attainments. In itself, this may not be especially significant since online courses are theory-oriented and students with higher levels of educational attainment would be better equipped to perform well in these courses anyway.
- Apprentices who perform well in traditional in-school courses are more likely to succeed in online courses. In SAIT's experiments with online learning, apprentices needed to achieve a grade of 80 per cent or higher in their introductory level courses to take intermediate and advanced courses online. To some degree, the correlation of online performance with a high level of performance in traditional classroom courses is entirely expected. Apprentices who performed better in the introductory level courses are likely to perform well in intermediate and advanced courses, regardless of the mode of training.
- Traditional in-class delivery affords more opportunities for instructors to recognize learning challenges and address them so this format may still be the best for those apprentices who struggle with their Essential Skills. In a traditional in-school course, learning difficulties manifest themselves within the first or second week. Remedial support can then be arranged. In online learning, learning difficulties are unlikely to be recognized, especially if there is no instructor support.
- Online learning focuses on the theoretical aspects of the trades that need to be understood. 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.
- One of the advantages of online learning is that apprentices can learn at their own pace. Some interviewees believed this helped apprentices achieve better test scores because they were able to review areas where they needed help before moving on to the next concept. The ability to review the material repeatedly was important for immigrant apprentices whose first language was not English.
- According to the interviewees, ownership of computers, internet access and basic computer literacy are sufficiently widespread among apprentices under the age of 30 that online technology should not be considered a significant barrier to participation in apprenticeship training.
- Online learning requires greater self-discipline. 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.
- There are mixed views on whether online learning is more suitable for advanced level courses or equally suitable for all levels.

- Instructors with experience in hybrid courses that combine online learning with in-school training believe that the interaction with an instructor for part of the course motivates apprentices and contributes positively to their performance.
- Online glossaries of key terms and concepts are valuable because they enable apprentices to review a definition in a timely way. Some written glossaries are accompanied by a verbal voice over. For those apprentices who struggle with reading, the voice over helps with comprehension and enables them to learn the correct pronunciation of terms.
- Interviewees emphasized that individuals differ in how they approach learning, and this is true of apprentices as well. Some apprentices will adapt easily to online learning and will flourish in an e-learning environment. Other apprentices will find any type of instruction that is not focused on the 'hands-on' experience to be unsuited to their learning style. Still others will need a combination of both models. Apprentices will always need diverse options in how training is delivered due to their different learning styles.

4.5.4 Advantages of Online Learning:

- Online learning is less costly for governments. Apprentices who take courses online do not need access to EI because they can keep working. The cost reduction is around $2,000 to $2,500 per apprentice assuming the EI entitlement is for six weeks at 55 per cent of the insured earning and at a hourly wage of $15 to $20.
- Online learning is less costly to apprentices since they can continue to earn their regular wage while doing the courses. Even with EI benefits, an apprentice loses earnings when they do their in-school training. Apprentices who can do online learning and do not have to travel to take their in-school training avoid the additional cost of accommodation and travel. For students in remote areas, not having to move can be a significant advantage, especially if they have a family. Organizations or governments that subsidize travel and accommodation costs will also benefit from lower costs. Access to online learning may help some apprentices complete their technical training and move towards the completion of their apprenticeship programs.
- For employers, online training eliminates the disruption to their operations when an apprentice leaves the workplace to attend technical training.
- For training deliverers, online learning frees up classroom space.

"It [online learning] is a bit of a stretch for the trades. Apprentices want everything to be hands-on. They don't come here to do computers and electronics. It's still a bit of a push to get them to use these systems."

College Apprenticeship Instructor in Motive Power Trades

"People who are in trades courses need teachers in front of them. Online doesn't really work."

College Instructor

"If you're going to learn online, you need initiative and self-motivation. You need to be able to plan your time."

College Instructor

"I think 20 percent of our apprentices would take to online courses. A better model would be to have a mix of online and in-school."

College Instructor

4.5.5 Criticisms of Online Learning:

There are two central criticisms of online learning. The first of these is that online learning is fundamentally unsuited to apprenticeship training because it detracts from the practical, 'hands-on' nature of trades training which appeals to apprentice learners. Some critics of online training cite Matthew Crawford's *Shop Class as Soulcraft*, a New York Times notable book in 2009 and also an Editor's Choice book in the *Financial Times*.[27] Crawford argues that there is an intrinsic value and satisfaction in actually performing skilled trades work.

The second criticism of online learning is that apprentices need the presence of instructors and online learning does not allow for that. In apprenticeship training, instructors 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. Taking the instructor out of the learning process or replacing the instructor with email communication puts the learning process at risk for a significant number of students.[28]

Some critics cite studies that show higher non-completion rates among students who take courses online.[29]

Other critics emphasize that online learning requires proficiency in Essential Skills and that many apprentices have weaknesses in this area. These critics warn that greater use of online delivery risks discouraging individuals from entering into apprenticeships because these individuals cannot see themselves taking courses online. While online learning may work for some apprentices, these critics believe that it is unsuited to a large majority of apprentices. These critics are also skeptical of pilot project results because they argue the pilots were focused on trades that have higher educational requirements and then selected candidates to participate who already had high grades.

27 Crawford, Matthew B., *Shop Class as Soulcraft*, Penguin (2009).

28 Cashion, Joan and Phoebe Palmieri, "The secret is the teacher: The learner's view of online learning", NCVER, Australia, 2002.

29 A recent a widely reported study is: Xu, Di and Shanna Smith Jaggars, "Online and Hybrid Course Enrolment and Performance in Washington State Community and Technical Colleges", Community College Research Centre, Teachers College, Columbia University, CCRC Working Paper No. 31 (March 2011).

Other skeptics of online learning point out that learning from a course ('structured learning') is a skill in itself and is different from 'learning by doing.' Many apprentices have been out of school for a number of years and adjusting to 'structured learning' can be a challenge. As such, many apprentices need the support and mentorship of an instructor as well as the interaction with classmates. These critics find studies of online learning that draw on the experience of full-time college or university students to be removed from the reality of apprenticeship training.

Online learning, like other types of distance learning, is often pursued after the completion of a day's work. In many cases, the apprentices will be tired. Their capacity to absorb new information, especially if it is complex, may be diminished.

4.5.6 The Economics of Online Learning:

There is a weak business case for extending the online model for colleges and training centres, contributing another barrier to expanding online learning.
As noted earlier, the cost savings of online learning for governments arise chiefly from reduced demands for income replacement under the EI system.
For apprentices, the cost savings include less travel and accommodation and the continued ability to earn regular wages. For colleges and training centres, the benefits are less clear. Setting aside facility costs, which are mostly a fixed cost, the principal cost of delivering in-school training is instructor time.
While the stand-alone model with no instructor support clearly eliminates the need for instructor time, there are few persons who advocate this model for apprentices. The instructor-supported model or the 'blended model' that combines online and shop training are the more common approaches. There is some indication that online students in instructor-supported and 'blended models' may interact *more* with their instructors and require more individual attention compared to traditional in-school training.[30] This reality is the opposite of what critics of online learning sometimes suppose.

"I have seen some health and safety courses through e-learning as well as other online courses, none of which I have found particularly effective."

Training Centre Director

However, if it is the case, then instructor time will be used differently, but may not be reduced significantly. Even if overall instructor time is reduced, the cost savings may not be commensurate with the costs of developing and maintaining an online course. Moreover, development costs are upfront costs while savings on instructor time, if they materialize, occur over time. The inference from this analysis is that, from the perspective of colleges and training centres, the economics of online learning are, at best, uncertain and possibly negative.

For post-secondary training, in general, colleges have incentives to develop online courses because they may be able to increase their registrations and expand their pool of potential students. In the case of apprenticeship, increasing registrations is not an incentive because the number of seat purchases is determined by the provincial and territorial governments. Understanding the economics of online training is an important factor in appreciating the impediments to its adoption. In the absence of external financial support for development costs, many colleges and training centres will find only a weak business case for extending the online model to apprenticeship training.

30 Downes, Stephen, *The Future of Online Learning* - Chapter Eight "The Economics of Online Learning" (2004). Available at: http://www.downes.ca/future/

4.5.7 Ownership Issues:

In addition to the asymmetric distribution of costs and benefits, the expansion of online learning is also held back by ownership issues. In the traditional in-school model for delivering apprenticeship training, curriculum materials are either developed by individual training delivery agencies (TDAs) or purchased from a third-party publisher of training resources. All of this training material is subject to copyright protection. In principle, the same model applies to the development of e-learning resources where ownership is vested in the developer of the material. This default ownership model, which was developed for an entirely different context, poses problems when applied to e-learning.

In the first place, when a TDA develops an e-learning resource, who owns the intellectual property that is embedded in that resource - the TDA or the developers? Under current practice, ownership would be determined by the nature of the employment contract between the TDA and the developers. In many cases, the employment contract is silent on this question. Ownership rights may be further complicated if public money is used to support the development of an e-learning resource. Funding contracts may alter the intellectual property rights of developers, and may create a conflict between funding contracts and employment contracts.

"Students will be at a real disadvantage if they don't know how to research things on the web."

College Apprenticeship Administrator

A second problem arises with the strict application of copyright to e-learning resources. The cost of developing curriculum materials for traditional in-school training is manageable for most training centres and colleges. The strict application of copyright in these circumstances does not hinder the development of effective learning resources. However, the cost of developing e-learning resources is substantially higher than the cost of developing traditional curriculum resources. As well, e-learning resources must be supported on an ongoing basis. The strict application of copyright prevents one college or training centre from incorporating materials developed by another college or training centre, even where this would be in the best interests of the apprenticeship system as a whole. The result is that development and support costs must be incurred many more times than is necessary.

Copyright and ownership issues will continue to constrain investment in e-learning until there is a better way to pool development costs and share ownership rights.

4.6 Learning Management Systems

Learning Management Systems (LMS) are software applications that manage all or most aspects of course administration, including registration, student record keeping, instructor management, course resources, and course design and delivery for an e-learning environment. The principle LMS applications are Blackboard, WebCT,[31] Desire2Learn,[32] Sakai, Moodle and Angel. WebCT and Angel are now owned by Blackboard. Sakai and Moodle are both open source, user-supported applications.[33]

LMS applications are both system management applications and systems for developing and delivering courses, whether in a traditional in-school setting or online. Virtually all colleges have implemented an LMS and some industry-based training centres have adopted LMS applications as well.

31 This resource was originally developed by the University of British Columbia.

32 Desire2Learn is a Canadian company.

33 Sakai is based in the U.S. and Moodle is based in Australia.

The widespread adoption of LMS applications is important for three reasons:

1. LMS applications require apprentices to manage their training through an account that is accessed online. Instructors communicate with apprentices through these applications, making email an important form of interaction. Apprentices 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.

2. LMS applications make it simple for instructors to host learning resources online and to refer students to those resources. In other words, online usage is effectively built into every course, including traditional in-school courses. Again, students who lack basic computer literacy or who do not have online access will be at a serious disadvantage.

3. LMS applications provide templates for designing and delivering courses in an online format. By doing so, LMS applications both encourage experimentation with online delivery and substantially reduce the costs of developing online courses.

LMS applications are potentially creating a gap between colleges and industry-based training centres. While LMS applications are virtually universal in the college system, only a minority of industry-based training centres have invested in these applications.[34] Should provincial and territorial governments decide to systematically expand the online delivery of apprenticeship training, colleges may be better positioned to respond than many industry-based training centres.

4.7 The Use of the Web as a Resource

It is increasingly common for instructors to provide course materials on the web or to direct students to sites that host resources. This trend is especially true for technical resources such as codes, standards, and manufacturer specification sheets and manuals. Assignments often require students to locate resources on the web. Instructors also report using Facebook groups to post information and compile useful web links. Many instructors believe that the pace of technological change makes it important for apprentices to develop their web-searching skills. To a substantial degree, the web is reducing the role of textbooks and handouts. Apprentices who use web resources need to be taught to verify the sources they are using as well as to check that the information is the most up-to-date available. In some colleges, apprentices may take theory courses that are actually part of a technology program. It is a common practice in technology courses to require students to bring a laptop to class and to direct students to research topics on the web.

4.8 Mobile Apps

Mobile apps are available to perform common calculations for many trades and to provide other technical resources. A scan of iTunes turns up hundreds of apps that are relevant to the construction and motive power trades. Instructors report that many apprentices use these apps and are aware that the use of apps is common in industry.

There is considerable variance in how colleges and training centres have responded to the ‘app phenomenon.’ At one end of the spectrum, there are some colleges and training centres that do not permit the use of smartphones in the classroom or shop. Apps are not part of the training standards and, therefore, are not a part of the curriculum. The use of apps is considered to be akin to cheating. At the other end of the spectrum, there are colleges and training centres that encourage the use of apps. Mohawk College, for example, hosts a website that describes more than 30 mobile apps that are relevant to various trades. SAIT reports that its faculty are developing apps for student use.

34 In the case of Moodle and Sakai, the main cost is staff time because the applications themselves are freely available.

5.0 On-the-Job Learning

This chapter describes trends that are relevant to apprentice on-the-job learning. Evidence from the interviews indicates that vendor-supplied training is becoming more important. There has been a recent and significant increase in the availability of e-learning products from industry associations. In the Canadian operations of global companies, the impact of corporate universities on training is also palpable. Taken together, these trends suggest that the environment for on-the-job training is changing. At least initially, these changes will be more evident in the manufacturing sector where vendor training, industry associations and corporate universities all play prominent roles as developers and suppliers of training. It is possible that the trends which have been described will be more evident among larger companies than smaller companies. In the construction industry, the impact of vendor-supplied training is also important, while the role of industry associations as suppliers of training is less obvious. In some branches of the service sector, industry associations are making an increasingly important contribution as suppliers for training. As international brands take on a more important role in the service sector, through licensing and franchising, the training that is associated with maintaining brand standards will also take on greater importance. This report suggests there should be more experimentation with electronic log books to track the on-the-job learning of apprentices.

5.1 Proprietary Technologies / Vendor-Supplied Training

As noted in Chapter 2, vendor-provided training is an important aspect of on-the-job learning for both apprentices and journeypersons. Vendor-provided training is often part of the package when technology is purchased. This training can be delivered through a range of channels including:

- off-site training of operating technicians and maintenance tradespersons,
- on-site training,
- online training, or
- train-the-trainer programs.

Online training that is provided by vendors to support their technology is particularly important for two reasons. First, companies that use vendors that provide training support through online channels will seek to hire apprentices who are familiar with this type of training or who can otherwise demonstrate an affinity for online training. Second, the quality of online training provided by vendors establishes a benchmark against which both apprentices and employers will evaluate online delivery of apprenticeship training.

5.2 Corporate Universities

There is a growing trend towards the use of corporate universities in training. In 1993, there were 400 companies that operated in-house universities. It is estimated that there are now around 3,700.[35] Corporate universities are established by companies to design and to deliver advanced training to their employees. Typically, this training is only available to employees of the company. The substantial investment that goes into these institutions ensures that management is continually aligning training to the human capital needs of the company. This focus is a critical feature of the training offered by these institutions. The standards underpinning the training are developed to reflect the company's needs. Portability is not an objective, nor even necessarily desired. Training is usually delivered in a campus environment, however, it is increasingly common for courses to be offered online. Some corporate universities also train employees in supply chain companies and the employees of customers. As the manufacturing sector becomes more globalized, the scope and importance of corporate universities will increase. The emergence of corporate universities is among one the most important trends in private sector human resources development.[36]

Many corporate universities focus on training managerial and engineering staff. However, there are examples of corporate universities that design and deliver training for the maintenance trades. For example, the technical school at Tenaris University, operated by the Argentina-based steel pipe-maker Tenaris SA, designs and delivers on-site, off-site and online training for all steel mill technical and operational workers.[37]

Corporate universities draw on an international pool of design talent. Their training products reflect leading edge approaches to design. As well, their development costs are spread over a global workforce, significantly reducing the per student cost of designing training resources. Virtually all of the training offered by corporate universities is aligned with the sponsoring company's operating strategy and its specific technological needs.

35 Denise R. Hearn, Education in the Workplace: An Examination of Corporate University Models www.newfoundations.com/OrgTheory/Hearn721.htm

36 Holland, P. & Pyman, A., "Corporate universities: a catalyst for strategic human resource development?" *Journal of European Industrial Training*, Vol. 30., 2006.

Annick Renaud-Coulon, *Corporate Institutes: International Evaluation and Comparison*, Global Council of Corporate Universities.

37 In Canada, Tenaris operates facilities in Alberta and Ontario.

5.3 Industry Associations and Sector Organizations as Suppliers of E-Learning Products

There are a number of industry associations and sector organizations that provide online training to the employees of member companies. While Canadian industry associations are generally not engaged in the direct delivery of workforce training, a number of U.S. industry associations have moved in this direction and it is common for Canadian companies to belong to these associations. There are numerous examples of workforce training products designed and delivered by U.S. industry associations that are available to their Canadian members. For example, the Metals Service Centre Institute, which represents independent distributors of primary metal products, offers a range of courses ranging from testing to heat treatment of metals. The World Steel Association supports Steel University that offers courses on metallurgy, handling of steel and safety in steel mills.

It is common practice for industry-based health and safety associations to deliver health and safety training online in addition to providing in-school and on-site training. Most apprentices will be exposed to this type of training during their apprenticeship.

Delivery of e-learning resources through industry associations or sector organizations is especially important to small and medium-sized enterprises which, in many cases, would not otherwise have the means to develop such resources.

5.4 Online Apprentice Log Books

Most apprenticeship administration authorities track on-the-job experience through a traditional log book that is completed by an apprentice and signed by a supervisor or journeyperson. For many stakeholders, the traditional log book will continue to be the most common way to track workplace learning. Some stakeholders, however, are experimenting with online methods. In B.C, for example, some equipment operating trades are using smartphone apps to upload information on hours worked into electronic log books. B.C.'s Northern Lights College has developed a web-based log book.

In Australia, the electrical and electronics industry introduced 'eProfiling' to facilitate the tracking of on-the-job training. This application tracks both accumulated hours and specific categories of experience. The gathered information enables those responsible for administering the apprenticeship systems to gauge whether apprentices are getting the breadth of exposure that the training standards anticipate. 'eProfiling' also increases employer accountability. In the U.S., the American Culinary Federation uses an electronic log book to track on-the-job experience for training in various food preparation trades.

There are a number of software developers that offer apprenticeship management applications that include web-based log book modules. Recordkeeper's Apprenticeship Tracker is used by a number of U.S. colleges and by the Sheet Metal Institute, which is a joint initiative of the Sheet Metal and Air Conditioning National Contractors Association and the Sheet Metal Workers International Association. McNeil Enterprises supports Apprentice Tracking System, which tracks in-school training as well as on-the-job experience.

While electronic log books will not be suitable to all trades and all workplaces, this approach to tracking on-the-job training and experience has potentially important advantages. In the first place, unlike a traditional log book, an electronic log book cannot be lost or destroyed, assuming there is appropriate back-up. Second, electronic log books enable apprenticeship administrators to monitor the breadth of on-the-job training and experience and, where appropriate, to take steps to ensure that the apprentice is receiving the scope of experience that is required. Finally, electronic log books, by providing 'real time' data to apprenticeship administrators, increase the accountability of employers. Regulations that are premised on traditional log books may discourage the adoption of electronic log books, even where this switch is both feasible and advantageous. In Ontario, the Employment Ontario Information System for Apprenticeship (EOIS-Appr) will have the capacity to e-manage on-the-job training. However, this module has not as yet been implemented. As with all e-management systems, there are development costs associated with electronic log book technology. In Canada, there has not been enough experimentation with the technology to gauge the magnitude of these costs or the scale of application necessary to make electronic log books financially feasible.

5.5 Online Technical Resources: Glossaries, Codes, Standards, Product Catalogues

Among the most common e-resources in industry is the online availability of technical glossaries, codes, standards and product catalogues. In many industries and trades, online resources have replaced traditional published resources. The ability to access these resources is often an expected skill.

6.0 Conclusion

Technology is having an impact on apprenticeship training and the pace of change has accelerated in recent years. To understand the nature of these changes and the implications for apprentice learners, CAF-FCA undertook a literature review and a series of interviews with employers, college instructors, and trainers. The research was organized around three main themes: industry trends impacting trades and skills requirements, the use and impacts of instructional technologies, and the impacts of e-learning on-the-job. A number of noteworthy trends were observed through the research.

Many trades are being impacted by technological change and this, in turn, is impacting the nature of training and the skills required by workers. Greater theoretical knowledge, the capacity to problem solve and troubleshoot complex pieces of equipment, digital skills, and computer literacy are increasingly important skill requirements for certain sectors. Significantly, employers' needs in these sectors are evolving and providing relevant and responsive training will be challenging. Some employers in manufacturing, resource-based industries and utilities feel that construction workers may no longer have the skills they need impacting workers ability to transition from one sector to another. Significant training may be required in order to support workers who want to change sectors. Another trend is employers' preference for online learning and the use of digital technologies at the workplace. Apprentices will need to be adept at online learning and digital technologies in order to prepare for the workplace learning and upgrading they will have to do throughout their careers.

Across the diverse trades and systems of apprenticeship training, instructional technologies such as 3-D software, simulation technology, streamed video, social media, online learning, learning management systems, the web, and mobile apps are impacting apprentice learning. The most transformative of these technologies and the costliest to adopt are likely to be simulation technology and online learning. According to the interviewees, 3-D software applications and simulation technologies are enhancing apprentice learning and the ability of apprentices to practice their skills in a safe environment. Online learning has advantages because it allows apprentices to learn at their own pace and helps reduce the costs of training. Other forms of instructional technologies are also helping apprentices learn, particularly if they have the computer literacy and digital skills to take advantage of them. These various technologies do not, however, replace real experience on the job site or the value of instructor-supported learning. No policy framework, prohibitive costs and copyright issues may pose barriers to the further expansion of online learning in Canada.

The trends suggest that the environment for on-the-job training is changing, especially in the manufacturing sector. There has been a recent and significant increase in the availability of e-learning products from industry associations and vendor training or corporate universities from other countries are being used. Maintaining Red Seal standards may be challenging when the trainers are unfamiliar with the requirements in Canada. Another workplace trend could be the use electronic log books to improve the tracking of apprentice on-the-job learning.

In order to discuss potential solutions to the challenges that lay ahead, ongoing dialogue about the impacts of technology on apprenticeship training will be critical.

7.0 Recommendations

Arising from both the literature review and interview input, a number of recommendations have been made for grappling with the challenges that technology poses to apprenticeship training.

1. Engage More Broadly with E-Learning, but within an Overall Strategy

Evidence from the interviews conducted for this report point to these broad conclusions about simulation technologies and online learning:

- There has been significant innovation in the use of both simulation technologies and online learning in the delivery of in-school apprenticeship training. This innovation, however, has been largely ad hoc. Where there is keenness on the part of instructors to try out these technologies, there is innovation and experimentation. Where there is resistance, however, innovation is much less likely to occur. There is no framework to identify priorities, fund investment in e-learning, monitor progress, share experience or evaluate results.
- While there are examples of notable innovations in the delivery of in-school apprenticeship training, there has been considerably more systemic engagement with e-learning in technology courses that are offered under the aegis of diploma programs. The apprenticeship community should remain open to exploring different forms of training delivery, as it reflects the reality of ongoing training in the workplace. As employers adopt online learning as part of their internal development process, tradespeople will be better prepared for lifelong learning if they are familiar and comfortable with online delivery.

- There is a broad consensus among apprenticeship stakeholders that most apprentice learning styles are different from persons who pursue full-time studies at a university, for example. Apprentices have a much stronger orientation to learn by doing. Hands-on, practical learning is fundamental to the skilled trades and to apprenticeship training. Many apprentices have been out of school for a number of years, generating a wide variance in apprentice readiness for e-learning. There is also a greater dispersion of language skills among apprentices. A successful e-learning strategy will need to take all of these factors into account. The apprenticeship systems need an e-learning strategy that is made for apprenticeship, not one that is a cookie-cutter adaptation of a strategy developed for other types of learners.

The principal drivers supporting the expansion of online learning in the apprenticeship systems is the reduction in costs to governments, apprentices and employers. These cost savings are real. For training deliverers, however, the picture is quite different. In the absence of external funding, training deliverers must bear the development costs of designing online courses. At the same time, in the absence of changes in seat purchase policies, training deliverers are limited in the number of apprentices they can train. Their costs of delivering almost any form of instructor-supported online training are likely to be similar to the costs of delivering traditional in-school training.

To engage more broadly with e-learning, the apprenticeship systems need a policy framework that takes account of funding, ownership and copyright issues, seat purchase restrictions, assessing apprentice readiness and supporting instructors in transitioning to more e-learning. A framework also needs to identify priorities and establish mechanisms for assessing progress and evaluating results. A policy framework for e-learning will need to consider the importance of Red Seal standards, creating e-learning products that reflect those standards. E-learning is not a substitute for hands-on learning. Learning by doing must always be a central part of apprenticeship. Nevertheless, e-learning does hold out the prospect of reducing overall costs to stakeholders, enhancing access to training and supporting increased completion rates. These benefits, however, may be partial and uneven in the absence of a comprehensive policy framework in each province and territory.

Concurrent with a broader engagement with e-learning, the apprenticeship systems also need to recognize that mobile apps are now an everyday technology and are frequently used in workplaces. A supportive approach to mobile apps reflects the realities of today's workplace and ensures Canada's tradespeople are knowledgeable about the resources available to them. This is an important element in ensuring tradespeople are using apps that reflect Canadian codes and standards, as well as metric measurements where applicable.

2. Computer Literacy and E-learning Readiness

Over the next decade, computer literacy will be a pre-requisite for an increased number of trades and for an increased number of apprentices. Three factors will drive the need for enhanced computer literacy: (1) in some trades, computer-based skills will take on increased importance, (2) learning trade skills will require computer literacy as more apprenticeship learning is delivered as e-learning, and (3) more companies will make computer literacy a requirement when hiring persons as apprentices.

Perhaps more subtle than computer literacy skills is e-learning readiness. Regardless of its format, online learning requires self-motivation, self-discipline and time management, as well as an environment free of distractions. In most online learning models, there is a time lapse, perhaps a day or longer, between when an apprentice seeks instructor guidance on a point and when that guidance is available. In the absence of advance screening for readiness, the evidence appears to indicate lower completion rates among online learners. When apprentices are screened for e-learning readiness, however, completion rates are on par with or superior to that of traditional courses. While some training deliverers suggest self-screening criteria, it is doubtful whether this is sufficient. It will be necessary to develop reliable and more objective screening criteria and to apply those criteria on a student-by-student basis.

When students have across-the-board difficulty with course material, especially theory courses, this becomes apparent within the first week or two of training in a traditional in-school course. Frequently, the learner's difficulties arise from weak math skills or reading comprehension challenges. When recognized early, these learning challenges often can be addressed with remedial support. This same opportunity for early detection is not available in courses delivered online. E-readiness assessments must screen for both attitudinal factors (e.g. motivation and time management) and for Essential Skills. Many apprenticeship training deliverers already test for Essential Skills and provide remedial training where needed. It will be important to understand whether the threshold level of Essential Skills is raised by e-learning and, if so, to what degree.

> **"If we followed only ministry guidelines, our apprentices would be way behind."**
>
> **Major Manufacturer**

3. Tension between Early Adopters of Technologies and Provincial/Territorial Training Standards

At any given time, there are industries that lead and those that lag when it comes to adopting new technologies. Within industries, some companies lead while others are slow to adapt. This diversity across the economy has always posed a challenge for the system of regulated trades. Figure 5 illustrates the tension between training standards which aim to cover widely-adopted technologies, and companies and organizations that fall outside that framework either because they are early or late adopters.

Figure 5:
Early/Late Technology Adopters and Provincial/ Territorial Training Standards

Early adopters of technologies often express frustration with provincial/territorial training standards because they are perceived to be outdated. Yet, late adopters will sometimes criticize mandated standards for being overly theoretical and providing training that is superfluous. This tension is inherent in the system of regulated trades and jurisdictional training standards.

The apprenticeship systems need to have a strategy for addressing the skill needs of technology-intensive industries as these companies and their technology strategies are defining the future skills needs for the economy as a whole. There are no 'cookie cutter' solutions to this challenge. Considerations include:

- In some trades, upgrading the standard across the board may be the most appropriate strategy. For some trades, this could imply increasing the amount of in-school training.
- In other trades, the apprenticeship systems may need to show more flexibility in enabling students to obtain a technician or technologist qualification concurrent with their apprenticeship. There are already programs of this sort available. For example, Ontario has the Co-operative Diploma Apprenticeship (CODA) program. The availability of these options may need to be increased.
- Apprenticeship systems may need to be more flexible in the sequencing of in-school training and on-the-job training. In particular, the apprenticeship systems may need to accommodate employers who wish to see the in-school portion of apprenticeship training fully completed before the on-the-job training begins.
- It may be desirable to provide scope for curricula innovation among training deliverers. The foundation of the current model for apprenticeship training is provincially/territorially mandated training standards. These standards leave little room for content that is over and above the mandated standard. It may be appropriate to explore a new balance between provincially/territorially mandated training standards and the autonomy of apprenticeship training deliverers. This move would preserve the important role of provincially/territorially mandated standards while also encouraging more innovation in both curricula and instructional technologies. This change would also allow the apprenticeship systems to make more use of the training resources provided by vendors, and engage these vendors more directly in supporting the apprenticeship systems.
- When employer-delivered training is structured around a curriculum and is broadly consistent with provincial/territorial training standards, consideration should be given to prior learning assessment or providing credit toward overall training requirements. It will be important, however, to guard against employer-specific training undermining adherence to approved training standards. Today, for the most part, employer-delivered training and apprenticeship training are two separate worlds. There is a potential strategic benefit to all apprenticeship stakeholders in a closer relationship between high-quality training delivered by employers, industry associations or sector organizations, with the goals of the apprenticeship systems.

4. Engage More Broadly with E-Management of Apprenticeship

The on-the-job component of apprenticeship training accounts for 80-85 per cent of an apprenticeship program, but monitoring may be limited and it can be difficult to know whether apprentices are progressing. Administrative records may, in fact, fail to show an apprentice has left the program entirely. E-management of on-the-job learning offers a low-cost solution which would enable those who are responsible for the quality of an apprentice's on-the-job learning to track experience as it is accumulated, assess progression and proactively identify problems. As noted, some segments of Australia's apprenticeship system use e-management systems to track on-the-job experience. With the advent of smartphones, it is now feasible for apprentices to log their hours electronically with the use of mobile apps. In workplaces with fixed work locations, it is rare for the company not to have an internet connection that would enable a web-based application to be used for logging hours and experience.

5. Documenting, Disseminating and Evaluating Innovative Practices

The apprenticeship community in Canada would benefit from a repository and disseminator of research on innovative instructional technologies in apprenticeship so that stakeholders in different jurisdictions could learn from the experience of others.

Funded by the Government of Canada's Sector Council Program Canada Financé par le Programme des conseils sectoriels du gouvernement du Canada