TRADITIONAL APPRENTICESHIP V. COGNITIVE APPRENTICESHIP IN THE ELECTRICAL TRADE: IMPLICATIONS FOR EDUCATION PROGRAMS

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CONTEXT

Becoming a member of a community of practice entails more than simply acquiring knowledge about the community's domain. Along with learning a body of facts the members ought to know, a newcomer is expected to develop competency in the tool-based practices pertinent to the domain, and to acquire heuristic strategies, or tricks of the trade. In the process of going from newcomer to journeyman electrician, different expectations of knowledge and proficiency are placed on the learner at different times.

Historically, the electrical community of practice in British Columbia reproduces itself through traditional apprenticeship (Crisford, 1936). For decades, electrical apprentices in the province have served a four-year apprenticeship consisting of 7200 hours of fieldwork and 1600 hours of formal education. Traditionally, newcomers to the electrical trade have been white males in their teens. These young adults worked, on average, for two to three firms during their four-year progress from newcomer to journeyman.

In recent decades, however, three factors have emerged that are putting new and severe pressures on the traditional apprenticeship model of entry into the electrical trade. The factors are: changes in the demographics of the individuals entering apprenticeship, increases in competition within the trade, and increases in complexity of the practices of the trade. First, the demographic profile of apprentices has become greatly varied: men and women of a variety of ages and backgrounds are now entering the trade, bringing with them many levels of existing knowledge and competency. Second, increased competition between electrical contractors has prompted firms to increase the number of apprentices working under an individual journeyman. The traditional one-to-one relationship between mentor and apprentice is largely a thing of the past. An effort to maintain a close mentoring relationship is still felt in the unionized workplace, where a maximum two apprentices to one journeyman ratio is enforced. In the non-union sector, however, there are no limitations to the number of apprentices assigned to a single journeyman. Non-union employers rely on senior apprentices to instruct and supervise less experienced ones. Often, apprentices in their last year will be managing crews of up to ten more junior apprentices (Racca, fieldnotes, June 2000). Lastly, the technical complexity of practices in the growth areas of the electrical trade continues to escalate. This requires both journeymen and apprentices to work with untraditionally delicate materials, and to interact closely with members of scientific and technological communities of practice. When working in these growth areas, both mentor and newcomer electricians are expected to possess unprecedented amounts of discursive resources and cognitive awareness.

Can the traditional apprenticeship model still generate an adequately prepared journeyman electrician? The impact of the factors outlined above is being felt at the core of the electrical industry, an industry that, now more than ever, is struggling to safeguard its identity and its claim to technologically advanced, fast-evolving, non-traditional areas of practice. Is the rigidity of traditional apprenticeship turning adult learners with established competencies away from becoming electricians? Is traditional apprenticeship generating electricians fast enough to address the needs of the labour market? Is the traditional apprenticeship model able to generate the critical-thinking, problem-solving communicators that the electrical industry needs as it interfaces with the other technologists and professionals that populate its growth areas? Our research is concerned with scientific and technological practice, and with the manner in which practitioners¾ newcomers and full members alike¾ are affected by shifts in the content and the context of their practice. In addressing the questions above we conduct long-term studies about knowing and learning in the electrical trade, both in formal (community college) and informal (field) settings.

PURPOSE

The reproduction of a scientifically- and technologically-oriented community of practice entails newcomers' acquisition of the body of facts and tool-based practices characteristic of the community. In the electrical trade, this is accomplished through a traditional apprenticeship¾ a learning process that occurs both in formal and informal settings, under the tutelage of established members of the community. This study investigates the degree of success with which the traditional apprenticeship model accomplishes this task. The study uses ethnography to document the teaching of scientific practices pertinent to the electrical trade, both in a trade program in a community college, and in a number of jobsites. The study also uses document and policy analysis to create a snapshot of the electrical trade as seen by the players involved in its mode of reproduction. Our data is contextualized through interviews with established members of the electrical, and with members of the governmental and educational infrastructure behind electrical apprenticeship. An analysis of the data was conducted to determine whether traditional apprenticeship¾ as opposed to cognitive apprenticeship¾ is still an effective model for the reproduction of the electrical community of practice.

THEORETICAL FRAME

This study was designed to investigate the effectiveness of the traditional apprenticeship model in preparing journeyman electricians that are adept and proficient in the precepts and practices of both traditional and non-traditional areas of the trade. Our research was informed by anthropological and ethnomethodological investigations of cognitive skills required in the completion of material activities (Brown and Duguid, 1992; Lave and Wenger, 1991; Roth, 1996). For our study of the reproduction of a community of scientific and technological practice we drew on the theoretical approaches and interpretive frameworks of other anthropological, ethnomethodological, and sociological studies of practitioners and apprentices at work (Coy, 1989; Latour and Woolgar, 1986; Lynch, 1985; Traweek, 1988). From this perspective, knowledge does not reside exclusively in people’s heads, rather, it is decisively constituted by the way people go about their daily business: for example, how they describe and justify what they do, the tools they use, and the practices they adopt. Our approach also considers findings indicating that technological practices belong to a form of scientific knowledge that is extremely difficult to communicate, and that often has to be learned from an expert practitioner in the context of its use (Collins, 1982; McCain, 1991; Roth, 1996). Our study is also guided by the work of Collins et al. (1989) on the nature of traditional apprenticeship and of cognitive apprenticeship, with particular reference to the communicative, problem solving, and critical thinking aspects of the latter.

RESEARCH DESIGN

The first author collected ethnographic data as he attended a total of eight months of community college-level trades program¾ first as a pre-apprenticeship student, then as a second-year apprentice¾ and as he worked for fourteen months as an electrical apprentice. Attention was paid to the manner in which scientific and technological practices were taught at the college and in the field, and to the manner in which journeyman electricians and higher-year apprentices imparted knowledge to newcomers. Document and policy analysis was also used to gain a snapshot picture of traditional apprenticeship as perceived by the union, industry, and government players involved in shaping apprenticeship in British Columbia. Data thus obtained was contextualized through interviews with established members of the electrical trade, with faculty members and program designers at the college, with governmental trade curriculum designers, and with members of the Industry, Training, and Apprenticeship Commission¾ the governmental body overseeing apprenticeships in the province.

Members of the research team reviewed the data corpus independently, building a series of assertions about the effectiveness of traditional apprenticeship in addressing the needs of learners in the growth areas of the electrical trade. Individual findings were debriefed in a group setting, members defending their interpretations. Tentative team assertions were reviewed in light of the data corpus, and were reformulated until they became representative of the data.

RESULTS

TRADITIONAL APPRENTICESHIP:
Learning practices and precepts in traditional areas of the electrical trade

Our team has reported earlier on learning long-established practices of the electrical trade through traditional apprenticeship (Racca, Bowen, and Roth, 2000). Traditional apprenticeship in the electrical trade is rooted in the tri-phasic model of apprenticeship suggested by Collins et al. (1989). The apprentice-journeyman relationship unfolds through three phases: modeling, coaching, and fading.

Modeling is an action carried out by the mentor journeyman as s/he carries out a task. The apprentice is offered an opportunity to observe the steps followed by the journeyman, and to build a conceptual model of the practice witnessed.

Coaching is an action carried out by the mentor journeyman as s/he assists the apprentice in the completion of a task¾usually one closely related to the practice just witnessed by the apprentice. The journeyman assists the apprentice through the task by offering hints and support.

Fading is also an action carried out by the mentor journeyman as s/he “fades” into the background, gradually removing their support until the apprentice is carrying out a practice competently on their own.

Within the framework of traditional apprenticeship, the apprentice alternates between periods of fieldwork and periods of formal instruction. Fieldwork is intended to expose the apprentice to as many practices of the electrical trade as possible. Formal instruction is intended inculcate in the apprentice the theory behind the practices learned in the field. The dichotomy between the apprentice as worker and the apprentice as learner that arises within traditional apprenticeship is discussed at length in an earlier article (Racca, Bowen, and Roth, 2000).

- Fieldwork in traditional apprenticeship

Exposure to practices while in the field remains a hit-and-miss situation in the framework of traditional apprenticeship. A 7200-hour apprenticeship can be served working for a single employer targeting a single task (eg. residential wiring), or can be served moving from employer to employer, exploring different niches of the electrical trade (eg. residential, commercial, and industrial wiring; cabling and communication; photovoltaic generation). No listing of core competencies to be possessed by all graduating apprentices is currently recognized or enforced in British Columbia.

Remuneration of fieldwork is based on the number of hours served in the field, not on level of training or on the apprentice’s level of competency. The pay scale clicks upwards by 5% of a journeyman’s wage every 900 hours served, starting at 55% of journeyman wage for a first-tem apprentice. This renders apprentices a desirable commodity for employers, as they represent cheap labour. The mastering of competencies and the level of formal instruction achieved by an apprentice bear no reflection on the apprentice’s pay schedule. Securing and maintaining employment in the later phases of an apprenticeship becomes increasingly difficult, as employers will favour cheaper, less skilled apprentices over more advanced ones.

At the core of fieldwork in an electrical apprenticeship is the notion of “putting in your time” (Racca, field notes, October 1999). This action is the *sine qua non* of the apprenticeship. Remuneration is linked to it, graduation time is linked to it, tradition is linked to it. In the minds of most journeyman mentors and employers, “putting in your time” is inextricably, yet inexplicably, linked with learning. There is currently no forum in the field component of an apprenticeship for the use of Prior Learning Assessment and Recognition (PLAR) in determining and awarding credit for an apprentice’s existing level of competency.

- Formal education in traditional apprenticeship

Formal education in an electrical apprenticeship is attained through four ten-week stints at a community college. The training periods all but exemplify the Instruction Paradigm heavily criticized in current literature (Barr and Tagg, 1995; Boggs, 1996; Barr, 1998). To attend their mandatory yearly training, apprentices are laid off from their jobs, and suffer a pay cut of 45% as they collect Employment Insurance. At the college, apprentices are effectively trapped into ten weeks of lock-step instruction of a modularized curriculum. No provision is made for Prior Learning Assessment and Recognition. The lock-step system does not allow for challenging individual modules of the curriculum, or for challenging an entire ten-week course by writing an equivalency exam. In an interview with a local Apprenticeship Counselor, the first author was inquiring as to the possibility of studying ahead for his third year schooling, and of challenging either individual modules or the whole ten-week course. Racca was informed that “one in one hundred apprentices ever asks about studying ahead”, and that no provision was in place for what he was requesting. The Apprenticeship Counselor summed it up thus, “Once you are in the system, you are stuck with it,” (Racca, field notes, January 2001).

The formal education curriculum is detached from the context of the field (Racca, Bowen, and Roth, 2000). This is the result of at least three factors. First, a substantial time lag exists between a curricular need arising in the field and the curriculum being modified to address the need. Second, the college curriculum is heavily slanted towards industrial applications in the electrical trade, as the International Brotherhood of Electrical Workers has historically overridden the needs of other employers in its demand that journeyman electricians be instructed in the practices of a small sector of the trade¾ one, however, that is union dominated. Third, jurisdictional interests dictate curriculum in a time when the electrical trade comes under attack by technologist trade associations. The electrical trade's claim to its growth areas is being challenged in the courts by technologist trade associations. These groups would like to have exclusive rights over areas such as data cabling and photovoltaic generation, and to see their own graduates employed in these lucrative niches. In staking jurisdiction, the electrical trade points to its training curriculum covering the contentious topics as its historical reason for being awarded exclusive rights over them. In an interview with the director of the Electrical Trade program at a local community college, the first author was told that the curriculum indeed only "pays lip service" to certain topics, but that those topics are there to entrench the trade's exclusive rights to the areas of practice in question (Racca, field notes, January 2001).

In an effort to increase consistency of curriculum delivery across the province, the material to be covered in the college component of the apprenticeship has been broken down into modules. The modules are compiled into individual booklets, each comprising sections on theory, solved problems, and practice problems. Modularization, however, has resulted in the further loss of a holistic view of the theoretical background to field practices: a college curriculum that already suffered from decontextualization (Racca, Bowen, and Roth, 2000) is now also suffering from fragmentation. College instructors throughout the province are voicing concerns about the shortcomings modularization (Sashaw, 2000).

NEW WINE IN OLD SKINS:
Observations on traditional and non-traditional practices in the electrical trade

Traditional apprenticeship in the electrical trade arose at the beginning of the twentieth century as a means to rapidly create a large number of individuals able to work with a new source of energy: electricity. Trained personnel was required to build a complex network of generation stations, high-voltage transmission lines, and low-voltage distribution lines to service virtually every factory and every home in North America. A new player emerged in the construction trade: the electrician. At the core of the electrician's abilities and identity were the precepts and practices of industrial and residential wiring. For fifty years, electricians became the people that could make available to consumers the latest labour-saving device: electricity as "work energy" (CECA, 1999). For fifty years, the traditional apprenticeship model provided a successful means for the reproduction of the electricians' community of practice.

Shortly before World War II, however, a discovery was made that imparted a new identity to electricity: a way of representing numerical data using electrical circuits was devised. From a seemingly humble beginning¾ on equals one, off equals zero¾ electricity as "information energy" became the core of electronic equipment, and of ever-expanding networks of digital computers. As local and global computer databases were devised, trained personnel was required to build a complex network of data transmission lines to service virtually every factory and every home in North America. Because of its traditional claim to installing wires, an existing player emerged to address the needs of information transmission: the electrician (CECA, 1999). At the core of this electrician's abilities and identity are the precepts and practices of data communication; programmable logic controllers; and computerized remote sensing, switching, and metering.

Practices related to the electrical trade are progressively segregating themselves into two categories. On the one hand there are long established practices, primarily pertaining to electricity as work energy, which have experienced few changes over the last three decades. Practices we investigated in earlier research, such as the bending and installation of conductor-carrying raceways, and the choice and installation of conductors, exemplify this category (Racca, Bowen & Roth, 2000). The evolution of these practices is slow, and techniques illustrated in wiring manuals from the thirties and forties (Graham, 1931) populate, almost unchanged, the pages of current training manuals (Province of British Columbia, 1999). The imparting of these practices follows a traditional apprenticeship model, with alternating periods spent by the apprentice in the field enacting the practice, and periods spent at the college learning the precepts behind the practice. <<a figure here may be good>>

On the other hand there are recently established practices pertaining to electricity as information energy: programmable logic controls, remote sensing and metering, and the transmission of data. These are fast-evolving practices, where rapid technological change requires continual updating of techniques and materials. Descriptions of these practices are covered in manufacturer-generated educational resources. These last are often in the form of CD-ROMs rather than printed text, as the fast evolution of the technology makes traditional manuals obsolete by the time they are printed. Up-to-date training in the growth areas of the trade is chiefly offered by manufacturers, rather than as part of apprentice training in the college.

The radically different nature of these two realms of practices poses a challenge to the traditional model of apprenticeship¾ so far the only government-sanctioned model of learning for newcomers to the electrical field. We have reported elsewhere on the dichotomy that arises in traditional apprenticeship between the imparting of precept and practice (Racca, Bowen, and Roth, 2000). Although less than ideal, the practice/precept split may be still acceptable with respect to the learning of long established practices. Because of the slow evolution of these areas of the trade, the time lag between learning to enact a practice in the field, and learning the scientific precepts behind the practice at the college may be unfortunate, but not incapacitating.

When it comes to recently established, fast-evolving areas of the trade, however, the understanding of the principles behind a practice becomes a pre-requisite to the enactment of the practice. Unless an apprentice has an understanding of the principle and causes of cross-talk (the interference that arises between two or more pairs of signal-carrying conductors when the cable is subjected to stress) in network cabling, the apprentice is unable to work on the installation without damaging the cable or otherwise reducing its performance. Similarly, unless an apprentice understands the nature and causes of attenuation (the drop in intensity of a light signal traveling through a fibre optic), the apprentice is unable to install runs of fibre optic without damaging the materials or affecting their performance.

A second element characterizes practices in the recently established, fast-evolving areas of the electrical trade. While the enactment of practices in the traditional areas of the trade yields individual, predictable outcomes, the enactment of practices in the growth areas of the trade yields ranges of outcomes. For example, the outcome of wiring a house light is “digital” in that the light either comes on when the switch is flipped, indicating that the practices were successfully enacted, or the light does not come on, indicating that one or more practices were not enacted successfully. By contrast, using data transmission as an example, data that is sent from the proximal end of an installation will indeed come out at the distal end (barring gross physical damage to the carrier). However, a number of variables¾ such as the degree of signal loss, and the degree of interference picked up by the signal¾ all contribute to the generation of an “analog” range of outcomes to the enactment of the practices. Suddenly the electrician is no longer delivering a “digital” outcome to the client, but is called upon to justify the performance of an installation that feature an “analog” range of outcomes.

<<table of practices & outcomes?>>

Practices in the growth areas of the electrical trade, then, differ from traditional practices in that they require the practitioner to be informed of the precepts behind the practices *before* the practices can be enacted successfully. Also, the success of enacting practices in the growth areas of the trade can no longer be measured as digital outcomes, but is rated over *analog* ranges of outcomes. This renders practices in the growth areas of the trade unique, and poses new challenges to the traditional apprenticeship model of accessing the electrical trade.

EMERGENT COGNITIVE APPRENTICESHIP:
Documenting a field-based learning model for non-traditional practices

Growth areas of the electrical trade are not immune to the pressures characterizing electrical work: construction schedules have to be met, time and materials have to be conserved, and finished products have to be delivered. However, because of the reasons outlined above, the characteristic view of the apprentice as a cheap set of hands to be unleashed with minimal training on virtually indestructible tasks (Racca, Bowen, and Roth, 2000) cannot be transferred to the growth areas of the trade. In the growth areas of the trade, enactment of practices is subordinate to an understanding of the precepts behind them. Given that the apprentices' college training does not address growth areas until the very last year of instruction, the onus of conveying both the precepts and practices pertaining to growth areas of the trade rests almost exclusively with the employer.

The necessity to educate an apprentice in the precepts behind the practices of growth areas of the trade before putting the apprentice to work in those areas creates unique niches of learning. In these niches, apprentices experiences closer mentoring and interaction with journeymen. Also, apprentices have the rare opportunity to experience contextualized learning, as theory is presented ahead of and in relation to enacted practices. The relationship between precepts and practices is continually explored in descriptions of the mental process behind an action, both by the mentor journeyman and by the apprentice. Conversation and "thinking out loud" characterize the dynamic between journeyman and apprentice. Lastly, the social dynamic behind precepts and practices is explored in the growth areas of the trade, as journeyman and apprentice work dynamically with the other players involved in a growth-area task.

As a third-term apprentice newly hired by the data cabling division of an electrical firm, the first author found himself in one such niche. Key to his success in becoming a useful, educated, and non-destructive apprentice was the emergent cognitive apprenticeship milieu that his journeyman intuitively set up. The first author was fortunate to be teamed up with Steve, a journeyman graduate of the school-of-hard-knocks who also understood the limitations of said androgogical system. Of his time working with Steve in a large governmental data storage facility, Racca writes:

> After months of being a disposable set of hands on the big industrial site, working with Steve just about brings on culture shock. I've shed my fifteen-pound tool belt, and walk around with a "data geek" pouch with precision cutters and termination tools. I've been introduced to, and routinely discuss my work with, the network manager, a system analyst, and a couple of programmers. I'm a player in a team not just of electricians, but of network builders. I wear a dress shirt to work, and my jeans stay clean. Some of the guys at the other site say that data is for sissies, but I happen to like it (maybe they're just envious).
>
> (Racca, field notes, September 2000)

And also:

> Steve is a talker. Whenever we enter a room, we do a walk-through, and he tells me how each piece of equipment¾ routers, hubs, switches¾ fits into the network. When we lift the floor tiles, or we open up a ceiling, he talks me through the existing components of the network, sensitive equipment to watch for, and connection points into which the expansions of the net we're building will tap into. All this information allows me to "see" appropriate routes for our cables and fibre optics the same way as he would. Steve talks about each path in terms of what it could do to the installation: sharp bends distort the internal structure of gigaspeed cables and cause crosstalk, a gigaspeed cable crossing over a fluorescent fixture picks up interference from the ballast and kills the signal to noise ratio. He walks me through his reasoning, and how the physics of data transmission end up dictating the choice of route for the installation.
>
> (Racca, field notes, December 2000)

Conversely, the emergent cognitive apprenticeship model Steve adopts with the first author is not only about making the mentor's reasoning manifest. Steve routinely calls Racca to task in justifying choices made in routing cables, and results attained in testing the performance of installation. Racca writes:

> Working with Steve is like a chess game: time is limited, yet every move is to be thought of in the context of three subsequent moves, and has to be informed with all moves previously witnessed. And I have to talk, I have to remember, I have to explain every bit that went into every choice. Slowly, mindfulness is becoming second nature.
>
> (Racca, field notes, February 2001)

Externalizing of reasoning appears to be a key ingredient to the exploration of precepts and their relationship to practices in the growth areas of the trade. Journeyman and apprentice "think out loud" to each other, and also discuss together solutions to obstacles encountered. Each suggests possible solutions, evaluating them in terms of their effectiveness in overcoming the obstacle encountered, and in terms of their potential impact on the performance of the installation. This type of dialogue, where apprentice's opinions are solicited and valued, is part of an overall picture of respectfulness that characterizes journeyman-apprentice dynamics in the growth areas of the trade. The uniqueness of emergent cognitive apprenticeship niches in the growth areas of the trade is not lost on the inhabitants of more traditional areas of practice, often espousers of the school-of-hard-knocks model for adult learning. Racca writes:

> I'm working flat on my belly, my head and arms inside the computer room floor. Somebody kicks my butt. I scamper out of my hole to see Steve, grinning.
>
> "What was that for?," I ask.
>
> "You'll never guess what somebody told me at the shop this morning," he says.
>
> "Yeah, what?," I ask.
>
> Steve replies, the grin fading: "They said I treat you too good."
>
> (Racca, field notes, December 2000)

COGNITIVE APPRENTICESHIP:
A learning model for both non-traditional and traditional areas of the trade

The learning model that is emerging in the field-based learning of non-traditional practices bears strong similarity with the cognitive apprenticeship model described by Collins et al. (1989). Cognitive apprenticeship originates from the tri-phasic structure of traditional apprenticeship, but includes three more components. Along with modeling, coaching, and fading, the acts of articulation, reflection, and exploration of ideas become central to the apprenticeship process (Collins et al., 1989).

Articulation is an action expected of both the apprentice and the mentor journeyman as they carry out specific tasks. The action entails both an exploration of background theory relating to the task, and an ongoing “thinking out loud” as the task is carried out. The cognitive processes behind the enactment of a practice are externalized, making them open to observation by the parties present. Each action is then verbally justified, and is contextualized in a theoretical framework. The narrated “walk-throughs” Steve did with Racca are an example of articulation.

Reflection is the process of comparison of the cognitive processes of the journeyman and of the apprentice, as externalized through articulation. Reflection allows for evaluation of choices made in carrying out a task, comparison of resources drawn upon in carrying out the task, and exploration of the theoretical background used in carrying out the task. Through reflection, the apprentice is offered an insight into the choices dictated by experience that characterize the cognitive processes of the mentor journeyman. Steve’s demand for Racca to externalize his reasoning behind a practice is an example of reflection.

Exploration is the process by which the mentor journeyman and the apprentice expand on the apprentice’s existing knowledge. This is attained by discussing theories and practices related to the task at hand, and by undertaking a new related task. The next round of action is again externalized through articulation, compared through reflection, and furthered through exploration. Discussions between the first author and Steve about pro’s and con’s of a given route for fibre optic is an example of exploration.

In a cognitive apprenticeship, attention is paid to content, methods, sequencing, and sociology (Collins et al., 1989). Content is not limited to domain knowledge¾ or the theory taught at the college. Content comes to include heuristic strategies, problem-solving strategies, critical thinking, and the development of discursive resources to interact with other players in a task. Steve's facilitating of Racca's interactions with network managers and other computer scientists exemplifies this component.

Cognitive apprenticeship also pays attention to sequencing, or timing, in the exploration of progressively more complex practices and theories. This aims at progressively building self-confidence in the apprentice, and moves away from the traditional notion of sink-or-swim apprenticeship. During the installation of a building automation system, Steve would leave the first author to work on his own for progressively longer periods, linked by cell phone, as he tended to other components of the project. Through this process, Racca developed the ability to budget time, requisition materials, and complete days' worth of work on his own (Racca, field notes, February 2001).

Cognitive apprenticeship sees learning as situated action. It focuses on the contextualization of knowledge through practice, on the social matrix behind tasks, and on the unique characteristics of individual learners. This makes cognitive apprenticeship a natural candidate for the application of Prior Learning Assessment and Recognition. By moving beyond the perception of the journeyman as the sole supplier of heuristic knowledge, and of the college as the sole purveyor of domain knowledge, cognitive apprenticeship opens a forum for PLAR in an apprenticeship setting. A cognitive apprenticeship is a place where the knowledge of theory and practices already possessed by an apprentice can be capitalized. In the building automation project, Steve assessed Racca's ability to work with programmable control modules based on the first author's training in electronics. Although unable to formally fast-forward Racca through his apprenticeship, Steve did assign to the first author increased independence and responsibility on the project (Racca, field notes, February 2001).

Finally, because of its recognition of the unique needs and assets of individual learners, cognitive apprenticeship is a place where self-paced learning, both in the field and in the college, becomes natural. Demonstrated mastering of learning outcomes, not hours and weeks spent on a job or at a desk, become the measure of success. This is where Steve's hands proved to be the most tied: in the end, it was the number of hours the first author had served in the field, rather than his competence, that determined Racca's wages.

THE POLITICS OF EDUCATION:
A snapshot of apprenticeship through policy analysis and interviews

The number of precepts and practices dealing with electricity as "information energy" has grown steadily over the last fifty years. However, the apprenticeship model has changed little in that time. The formulaic notion that

7200 hours of fieldwork + 1600 hours of college training = 1 journeyman electrician

has not been reviewed by the Industry, Training, and Apprenticeship Commission (ITAC) ¾ the provincial decision-makers in matters of apprenticeship timelines and curriculum¾ in light of the escalating number of precepts and practices of the electrical trade. To the contrary, the traditional apprenticeship model demands that precepts and practices pertaining to growth areas of the trade be mastered along with precepts and practices in the area of industrial and residential wiring, and that proficiency in the growth areas of the electrical trade be attained concurrently with proficiency in traditional areas of the trade. All this within a timeline originally designed for the learning of a far more limited number of traditional precepts and practices.

- Of timelines and curriculum

Rapid evolution in the electrical trade is to be found in the following growth areas: programmable logic controllers; data communication; and computerized remote sensing, switching, and metering. These areas are at the interface between the electrical trade, electronics, and engineering. In an effort to prepare journeyman electricians that are knowledgeable in the growth areas, the college curriculum pertaining to traditional areas of the trade has been progressively advanced to pre-apprenticeship courses and to the first of the four ten-week apprentice training periods. By their second ten-week training period at the local trade college, electrical apprentices are covering topics that closely mirror the curriculum for second-year university courses in electrical engineering (University of Victoria, 2001). The attempt to cover an ever- expanding curriculum in the traditional forty-week time span has been creating tension among curriculum deliverers province-wide. In an unexpected in-lecture monologue lamenting this phenomenon, one of Racca's instructors at the college went as far as calling the curriculum for the first ten-week training period "un-teachable" (Racca, field notes, May 2000). This instructor's views were echoed in the concern expressed at the October 2000 meeting of the Provincial Trade Advisory Committee, where an evaluation of the present curriculum by instructors province-wide was reviewed. In the opinion of the instructors, the increasingly voluminous curriculum did not flow well, and the teaching materials were described as "difficult to work with in the classroom" (Sashaw, 2000).

The Provincial Trade Advisory Committee (Electrical)¾ an advisory body composed of educators, industry representatives, and union representatives¾ presented to ITAC their concern about the ongoing expansion of the electrical trade curriculum not being accompanied by an expansion of teaching and learning time at the college, or at least a revision of teaching and learning methods. Their concerns were given a forum by ITAC, and a focus group of twenty-three instructors met for two days to restructure the curriculum. The guidelines for change the focus group was offered, however, did not comprise an expansion of the college training periods. In the end, the most the instructors could do was to shuffle curriculum modules around so that a seemingly more meaningful grouping of topics was attained (Sashaw, 2000).

- Of Prior Learning Assessment and Recognition

Well-defined assessment models have been developed to establish the knowledge level of workers transferring between trades, and have been used in provinces such as Ontario in order to grant them advanced placement in the college component of apprenticeship (Maxwell, ____). According to the 1999/2000 Annual Report on Prior Learning Assessment in British Columbia, our province is following suit through the integration of PLAR into a number of post-secondary training program, including Nursing, Adult Basic Education, Applied Business Technology, and Visual Arts, Media, and Design (Centre for Curriculum, Transfer, and Technology, 2000). Prior Learning Assessment and Recognition (PLAR) has been integrated in the pre-apprenticeship training offered by the Electrical Department of the local college. Contrary to the situation in Ontario, however, PLAR has thus far not been integrated in the traditional apprenticeship model of entry into the electrical trade.

In British Columbia, the integration of PLAR into trade apprenticeship is a decision that ultimately rests with the Industry, Training, and Apprenticeship Commission. Employers, educators, and curriculum developers in a number of trades have long voiced their concern about the lack of PLAR opportunities in traditional apprenticeship. Their concerns stem from the need to rapidly generate trained journeymen in light of an impending skilled-labour shortage. Concerns also arise from the lack of draw apprenticeship programs experience as a consequence of the lack of acknowledgement of the existing skills of mature workers retraining into a trade.

In February 2001, ITAC offered the above parties a forum: a focus group of their exponents would meet for two days under the auspices of ITAC to develop a policy document on the integration of PLAR into apprenticeship in British Columbia. The first author was asked to participate in this focus group. Strategies were discussed for the implementation of established assessment and recognition models trade apprenticeships. Answers were developed to the alienation of knowledgeable workers out of traditional apprenticeship, and to the sense of lagging behind provinces such as Ontario in our ability to recruit and retain apprentices. At the end of the two days, however, ITAC withdrew its request for a policy document, and simply asked that minutes of the meeting be submitted (Racca, field notes, February 2001).

- Of post-journeyed training as cognitive apprenticeship

Requests by educators, employers, and curriculum developers for a re-assessment by ITAC of the effectiveness of traditional apprenticeship as a means to generate new journeymen¾ especially so in the electrical trade¾ have been met with overwhelming institutional inertia. There appears to be a propensity by ITAC to fund an assortment of studies and of focus groups as concerns about the traditional apprenticeship model arise. The range of influence given to the recommendations of studies and focus groups, however, has proven minimal.

Concerns about the ability of traditional apprenticeship to fulfill its mandate have led some of the players in that educational model to stake out a new territory, where they propose to offer professional development opportunities lacking in the framework of traditional apprenticeship. Members of the Provincial Trade Advisory Committee (Electrical) and of the Electrical Program Advisory Committee at the local college have been spearheading the organization of “a non-partisan organization called the Electrical Industry Accreditation Society,” which “would allow the electrical trade to deal with its changing training requirements and promote industry acceptance of certification provided” (EPAC, 2000). In an interview with the head of the Electrical Department at the local college, a key player in the proposed Electrical Industry Accreditation Society, Racca was informed that the Society would offer courses for journeyman electricians in the growth areas of the trade now poorly addressed in traditional apprenticeship. Courses would focus on learning practices in the context of their accompanying precepts, on critical thinking, and on problem solving. The Society would also offer PLAR opportunities to journeyed electricians wanting to have their existing knowledge accredited (Racca, interview, February 2001). In short, the Electrical Industry Accreditation Society would offer a form of post-journeyed cognitive apprenticeship to the graduates of a traditional apprenticeship, giving them a taste of the training and recognition of knowledge they had not received as apprentices.

- Of babies and bath water

The emergence of the Electrical Industry Accreditation Society as a forum for cognitive apprenticeship is laudable, but also poses serious questions about the effectiveness of the traditional apprenticeship model upheld by the Industry, Training, and Apprenticeship Committee. Is traditional apprenticeship so entrenched in the government’s view of trade education that the sole forum for PLAR and for training in the growth areas of the electrical trade is remanded to a time *after* the completion of the apprenticeship? Does an apprentice have to invest in four years of traditional apprenticeship before being able to access, as a journeyman electrician, the mentorship and acknowledgement that accompany post-journeyed professional development? If so, will adult learners in the electrical field continue to submit themselves to the inflexible structure of traditional apprenticeship, in hopes of a better learning experience once journeyed, or will they opt for other training programs? It is crucial to remember that, in the same four years that are demanded of a learner to complete a traditional apprenticeship in the electrical trade, the individual could complete a co-op degree in electrical engineering. Through this route, the individual would emerge with a sizable amount of work experience, and with knowledge of precepts and practices of the electrical trade at least equivalent to that of a journeyman electrician. The individual would also possess a far greater earning potential, a higher social status, and a lesser need for the “further training” advocated by the Electrical Industry Accreditation Society for the graduates of a traditional electrical apprenticeship.

Have the non-ITAC players in traditional apprenticeship given up on this learning model ever evolving into cognitive apprenticeship? Given the massive institutional inertia of ITAC, given the history of studies and two-day focus groups pouring suggestions into an unchanging system, and given the recent emergence of the Electrical Industry Accreditation Society, it would be safe to say that, indeed, they have. Rather than attempting to effect change within the framework of the four-year traditional apprenticeship, the non-ITAC players have set their sight on post-journeyed training. In his interview with the head of the Electrical Department at the local college, the Racca was reminded that “electrical work requires life-long learning” and that “the four years of apprenticeship go by so fast” that there was truly little purpose in attempting to change the existing system (Racca, interview, February 2001). It is our opinion, however, that to surrender to an anachronistic model of apprenticeship while focusing on the development of post-journeyed training is tantamount to throwing away the baby with the bath water. Acceptance of the fallacies of the present apprenticeship model simply excuses institutional inertia, forcing apprentices in British Columbia to invest four years in an outmoded educational model, and then forcing them to invest in a series of costly post-journeyed courses just to come up to par with apprentices that trained in Ontario.

DISCUSSION

Despite extensive efforts by ITAC to recruit and retain larger number of apprentices, as reported in their Accomplishments, Results, and Outputs Summary, August 1999 to December 2000 (ITAC, 2000), apprenticeship in British Columbia is still not interfacing effectively with high-school trade training, and with previous learning attained by established workers. Four years of lockstep work and schooling at a fraction of the wages of a journeyman electrician do not make for an attractive proposition for adult learners with real-life responsibilities. Furthermore, the traditional apprenticeship model currently in place in our province fails to enforce the exposure of apprentices to a prescribed set of practices while in the field. It also fails to expose apprentices to many of the precepts pertaining to the growth areas of the trade while in the college, as it attempts to cram more and more curriculum items in an unchanging amount of learning time.

Crucial to the growing ineffectiveness of the traditional apprenticeship model in the electrical trade is the failure to implement Prior Learning Assessment and Recognition, and to provide a contextualized learning environment where a well-defined set of practices is learned concurrently with their accompanying precepts. Also, as long as progression through the apprenticeship remains lockstep, and as long as remuneration remains linked to time served rather than to abilities demonstrated, little fostering of intrinsically motivated learning is offered to the apprentices. Finally, the traditional apprenticeship model fails to address the need for apprentices to develop critical thinking and discursive resources. These are crucial to the ability of apprentices and journeyman electricians to interact with other players in the growth areas of the trade, and to externalize metacognitive processes when engaging in diagnostics, in problem solving, and in the training of apprentices.

Attempts to aid in the evolution of traditional apprenticeship in the electrical trade into cognitive apprenticeship have been blocked by institutional inertia. This has led non-governmental players in the apprenticeship process to create a post-journeyed forum for cognitive apprenticeship, a sort of graduate school for electricians. The proposed Electrical Industry Accreditation Society may in fact offer a learning opportunity that closely parallels cognitive apprenticeship (Cash et al., 1996): its offerings are PLAR-friendly, precepts are contextualized in practices, emphasis is placed on critical thinking and discursive resources. However, post-journeyed training does little to offset the impact of the traditional apprenticeship model on the number and quality of graduating journeyman electricians in British Columbia.

Below is a picture of what field work and formal instruction would look like in the context of a cognitive apprenticeship. Prescriptive steps towards the achievement of a cognitive apprenticeship model for the electrical trade in British Columbia are also presented.

- Fieldwork in cognitive apprenticeship

In the context of a cognitive apprenticeship, fieldwork would be equated with the acquisition of a set of Core Competencies, not with the “putting in” of 7200 hours of undefined work. In order to make cognitive apprenticeship a reality the Government of British Columbia, in the form of the Industry, Trade, and Apprenticeship Commission, would establish a list of Core Competencies to be possessed by all journeyman electricians in the province. Field officers at the Industry, Trade, and Apprenticeship Commission would liaise with electrical firms province wide to ensure that apprentices anywhere in British Columbia have an opportunity to fulfill all of the Core Competencies. For apprentices, this may entail traveling to different employers at different stages of the apprenticeship, and may lead to the specialization of some employers in exposing apprentices to particular competencies. For example, the pulp mill in Crofton, on Vancouver Island, may offer four-week employment opportunities for apprentices to gain exposure to programmable logic controllers (PLC’s) in an industrial setting. Apprentices working in the south of Vancouver Island would be given a leave of absence by their regular employers to work for the mill and fulfill the competency in question. The mill would in turn benefit from training the apprentices in knowing that their future hiring of journeyman electricians will not entail a from-the-ground-up training in the use of PLC’s.

Completion of Core Competencies would be linked directly to remuneration, and in turn to increased responsibility on the jobsite. Once an apprentice has completed a core competency, the apprentice would be expected to function in a journeyman-like role in tasks pertaining to that competency, the overall aim being to progressively bring the apprentice into the role of journeyman electrician. Completion of Core Competencies would also be linked to progression through the apprenticeship, each completed competency placing the apprentice one step closer to graduating as a journeyman.

- Formal education in cognitive apprenticeship

Formal education in the context of cognitive apprenticeship would require a shift from the Instruction Paradigm currently characterizing trade schools. A movement to the Learning Paradigm (Barr, 1998) would be imperative in order to foster cognitive apprenticeship. The key components of formal education in a cognitive apprenticeship are the recognition of learning outcomes, the design and implementation of a readily upgradeable curriculum, the introduction of authentic assessment of learning outcomes¾ including the use of Prior Learning Assessment and Recognition¾ and the creation of a self-paced learning environment.

In the same way in which core competencies would be recognized and defined in the fieldwork component of the apprenticeship, learning outcomes would be identified for the formal education component. A list of learning outcomes would be arrived at through the input of representatives of the electrical industry, labour, and government. A body similar to the existing Trade Advisory Committee¾ currently made up of employers, union spokespersons, and governmental advisors¾ would address this issue. Contrary to the current makeup of the Trade Advisory Committee, however, the proposed decisional body would also include apprentice representatives.

Once the learning outcomes are recognized, a curriculum would be designed to facilitate the apprentices' mastering of the selected outcomes. The existing modularized curriculum can lend a foundation to the proposed curriculum. Material offering a bird's eye view of the specific learning outcomes, and of the manner in which they fit into a holistic view of the electrical trade would have to be developed. Modules addressing individual learning outcomes would be grouped topically, so that proper sequencing would be maintained within the spectrum of a given learning outcome. For example, the subject of alternating current theory¾ currently split up over two college furloughs, separated by a year in the field¾ would instead be grouped under a single learning outcome, with modules addressing single phase systems having to be mastered before modules addressing multiphase systems can be tackled. Avoiding lengthy delays between iterations on individual topics would contribute to a more organic understanding of the subject matter. Finally, the curriculum would be converted into learning materials that are easily upgraded. On-line modules would be the best medium, reducing the time lag between the introduction or upgrade of a given learning outcome, and its availability to apprentices.

Formal education in a cognitive apprenticeship would demand the introduction of authentic assessment of learning outcomes. The current notion of closed book multiple-choice exams as the measure of mastery of an outcome is not representative of the reality of work in the electrical field. Resources such as reference manuals and copies of the Canadian Electrical Code are continuously available to apprentices in the field, and should therefore be made available during the assessment of learning outcomes. Conversely, bubble sheets as a means of communication are not a reality of work in the electrical field, and should not become the instrument of choice in the assessment of learning. A first component of assessment, then, would consist of authentic problems, to be solved in an environment rich with authentic resources. Along with a numerical answer, the apprentice would have to provide a verbal or written "thinking out loud" of the problem-solving process adopted. A second component, very much part of fieldwork but absent in current formal instruction, would be the presentation of one's understanding of a topic through verbal or written explanations. The apprentice's holistic mastering of a learning outcome would be assessed through oral presentations or through essays. These assessment formats would lend themselves to use in establishing and recognizing prior learning. Also, they would highlight the confidence level in an apprentice's understanding of the subject matter<<find reference about rating one's level of certainty of an answer>> Finally, they would create an opportunity for apprentices to practice articulation of their cognitive processes, better preparing them to be the mentor journeyman electricians of tomorrow.

The creation of a self-paced learning environment would be key to the formal instruction component of a cognitive apprenticeship. The use of lock-step programs has been challenged in its assumption that all students learn equal amounts of material in equal amounts of time, yet still permeates the learning environments of community colleges across North America (Barr, 1998). As learning outcomes are identified, and a curriculum and assessment scheme are developed, a self-paced learning environment must be created to ensure that the course of learning closely matches the cognitive and sociological needs of an apprentice. The learning of a given piece of domain knowledge would be timed by individual apprentices to accompany their field-based learning of the matching practices and heuristic strategies. Of equal importance in maintaining a high level of motivation in the apprentice, a self-paced learning environment would also avert apprentices' resistance to lock-step stints at the college, stemming for one from the financial loss currently attached to "going to school."

In conclusion, it is our belief that an emergent model for cognitive apprenticeship has already developed out of necessity in the growth areas of the electrical trade. This emergent cognitive apprenticeship model bears uncanny resemblance to the cognitive apprenticeship model described by Colin et al. (1989). Cognitive apprenticeship can be implemented as a model for learning in both traditional and non-traditional areas of the electrical trade, bringing to the electrical trade the same success it has brought to other trades (Cash et al., 1996). Steps to the implementation of cognitive apprenticeship in the electrical trade are not necessarily costly, but do call for a revision of established roles and power dynamics among government and industry players in electrical apprenticeship.

Our prescriptive steps for the contextualization of the college materials through the creation of college-based zones of legitimate peripheral participation (Racca, Bowen, and Roth, 2000) offer a viable though temporary option to updating the apprenticeship model for the electrical trade. The narrowing of the field-college gap, however, does not appear sufficient for the creation of an attractive and inter-provincially competitive apprentice model for the electrical trade. Our earlier prescriptive steps offer a useful temporary scaffold to a deeper reform of the electrical apprenticeship along the prescriptive path we are now offering.

It is our hope that a shift from the traditional apprenticeship model to the cognitive apprenticeship model will come into place in British Columbia. It is only through a revision of outdated learning models and social values that new generations of apprentices will be attracted to the electrical trade, and new generations of well rounded, informed, and integrated journeyman electricians will be created. Electricians training in our province are expected to master precepts and practices relating to electricity in both its forms¾ work energy and information energy. They are the new wine of the electrical industry, and they merit better than old skins.

Below is a vignette of what cognitive apprenticeship may look like for an electrical apprentice in a not-so-distant future:

- Cognitive apprenticeship: a best-case scenario

> It’s the end of my third day on the fibre job at the graving dock. My journeyman was there all along, and he was great with answering questions, but this was really my job to run, from going over the spec sheets, to pulling in the fibre, to terminating it and testing it. I’ve had to inspect the site, I’ve had to finalize a route, I’ve even had to think about weather forecasts. It looked like snow when we pulled in the fibre, and I was concerned that it’d be too cold and that the jacket on the bundle would retain too much of the shape of the coil, making it hard to feed it between manholes without kinking it. But in the end it warmed up outside, and we had the perfect sunny January day, and, aside from stepping into a couple manholes full of water, the pull went as smooth as I could wish. I was glad I estimated the time just right for the bucket truck to show up, and we were able to get the fibre out of the ground and up a pole, and string it up all the way to the environmental monitoring lab. Today was hectic, terminating and testing the fibre, and discussing the test results with the computer engineer (they always want it to perform better than the installation will allow). But anyway, the water quality sensors are now hooked up in the pump house and their output is flying up my fibre run to the computers in the envirolab. This job gives me the credit for Optic Fibre Installation and Termination: it’s one more Core Competency out of the way, putting me that much closer to being journeyed, but it’s also an increase of fifty cents an hour in the old pay-check! Tonight I will go on-line and take the exam for the Fibre Optic Module for self-paced school. It’s great to get the Core Competency recognized at work, getting paid more for it, and then writing the exam and getting credit for the equivalent piece of theory at school. I sure don’t miss the “old days” of having to warm up a desk for ten weeks a year whether you need it or not… Hey, I just realized that I did do photovoltaic generation in my electronics course way back when. I bet that if I find my transcript I can get credit for that module. If not I can at least review my old notes, and I can write that exam on-line for school right away!
>
> (Joe Apprentice, diary entry, January 20??)

IMPLICATIONS FOR EDUCATION PROGRAMS

Numerous vocational adult education programs find themselves at the interface between traditional and recently established domains of knowledge and practice. Efforts to recruit and retain learners in vocational adult education have met with reduced success (CECA, 2000). This can be viewed as the result of two primary factors. First, a widening gap is forming between the level of skill and academic preparation presented by adult learners and the amount of recognition¾ both academic and financial¾ it is given in traditional learning models. Second, traditional learning models are ill equipped to keep pace with the evolution and expansion of recently established domain of knowledge and practice.

In order for vocational adult education programs to remain attractive and competitive, programs must adopt protocols for assessing and recognizing prior learning. Second, education programs must provide learners not only with factual knowledge and manual skills, but also with the metacognitive and discursive resources needed to interact with members of adjacent communities of practice. Our findings call for a restructuring of electrical apprenticeship from a traditional apprenticeship to a cognitive apprenticeship, as defined by Collins at al. (1989). Cognitive apprenticeship has been successfully implemented as a model for adult learning in the automotive trade (Cash et al., 1996). However, learning through "modeling, coaching, fading, articulation, reflection, and exploration of ideas" does not have to be restricted to the trades. Cognitive apprenticeship offers a learning-centered model (Barr, 1998) that can be applied to a variety of education programs, both academic and vocational. By maximizing the value of prior learning, and by narrowing the gap between precept and practice, cognitive apprenticeship would be the learning model of choice for programs aimed at generating informed, skilled, employable, fulfilled, critical-thinking, problem-solving individuals.

REFERENCES

Brown, J. S., and Duguid, P. (1992). Enacting design for the workplace. In P. S. Adler and T. A. Winograd (Eds.), *Usability: Turning technology into tools* (pp. 164-197). New York: Oxford University Press.

Cash, J. R., Behrmann, M. B., Stadt, R. W., and McDaniels, H. (1996). Effectiveness of cognitive apprenticeship educational methods in college automotive technology classrooms. *Journal of Industrial Teacher Education, 34* (2), 29-49.

Collins, H. M. (1982). Tacit knowledge and scientific networks. In B. Barnes and D. Edge (Eds.), Science in context: Readings in the sociology of science (pp. 44-64). Cambridge, MA: MIT Press.

Collins, A., Brown, J. S., and Newman, S. E. (1989). Cognitive apprenticeship: Teaching the craft of reading, writing, and mathematics (Technical Report No. 403). Cambridge, MA: Bolt, Berandack, and Newman.

Coy, M. W. (1989). Being what we pretend to be: The usefulness of apprenticeship as a field method. In M. W. Coy (Ed.), *Apprenticeship: From theory to method and back again* (pp. 115-135). Albany, NY: State University of New York Press.

Latour, B. and Woolgar, S. (1986). *Laboratory life: The social construction of scientific facts*. Princeton, NJ: Princeton University Press.

Lave, J., and Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge: Cambridge University Press.

Lynch, M. (1985). *Art and artifact in laboratory science: A study of shop work and shop talk in a laboratory*. London: Routledge and Kegan Paul.

McCain, K. W. (1991). Communication, competition, and secrecy: The production and dissemination of research related information in genetics. *Science, Technology, and Human Values, 16,* 491-516.

Orr, J. E. (1998). Images of work.*Science, Technology, and Human Values, 24,* 439-455.

Racca, R. L., Bowen, G. M., and Roth, W.-M. (2000). *Learning scientific practices in the electrical trade: Implications for education programs*. Paper presented at the 2000 annual meeting of the American Education Research Association - New Orleans, LA.

Roth, W.-M. (1996). Knowledge diffusion in a Grade 4-5 classroom during a unit on civil engineering: An analysis of classroom community in terms of changing resources and practices. *Cognition and instruction, 14,* 179-220.

Traweek, S. (1988). *Beamtimes and lifetimes: The world of high energy physicists*. Cambridge, MA: MIT Press.