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Why are occupational health and safety training approaches not effective? Understanding young worker learning processes using an ergonomic lens

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ABSTRACT

Young workers are frequently injured at work. Education and awareness strategies to prevent injuries among young workers are common but they are often ineffective. These approaches emphasize teaching, rather than learning strategies, and appear to contradict recent competency-based developments in education science. This study aimed to gain insight into the actual safety skills learning process of adolescents in an internship in a high school vocational training program. The results are based on auto and allo-confrontation interviews from an ergonomics intervention study with nine apprentices and five experienced coworkers involved in the training. This technique is suited to obtaining qualitative data on work activities; it consists of interviewing apprentices and co-workers about videotaped work observations to capture the thought processes behind their action. The findings reveal that learning in an actual situation poses challenges because working conditions and also learning conditions are not always optimal. Such conditions prompt apprentices to develop novel strategies to manage unexpected situations. At times, this involved side-stepping a safety rule in order to meet work demands. The use of an ergonomics actual work activity approach allowed the merging of two research topics rarely found together: the socio-ecological paradigm in education and the development of original interventions to prevent occupational injuries among young workers. This intersection of educational theory and injury prevention strategies provides new avenue for improving vocational training programs and developing primary prevention interventions in occupational health and safety programs that target youth.

1. Introduction

Young workers are more likely to be injured at work than older workers (Breslin and Smith, 2005; Laberge and Ledoux, 2011) and this appears to be related to inexperience. As shown by Breslin and Smith (2006), short job tenure is a stronger predictor of occupational injury than age. Similarly, Sorock et al. (2001) showed that work accidents happen more frequently while the worker is performing an unusual task. Although work injury rates in Quebec have been in steady decline since 2000 (CSST, 2012), certain categories of young workers remain at relatively high risk of work injury: those who leave school early, experience learning difficulties, and who hold manual and unskilled jobs (Breslin, 2008; Breslin and Pole, 2009). Young people with learning difficulties are more exposed to workplace hazards (Breslin and Pole, 2009). Interestingly, workplace factors more strongly explain occupational injuries among young people than do individual and developmental characteristics (Breslin and Smith, 2010). Essentially, epidemiologic models have shown that young people frequently hold manual and unskilled jobs and these are strongly associated with high occupational injury rates (Breslin et al., 2007; Breslin and Smith, 2010). Primary injury prevention for young workers remains important, and research programs targeting this youth subpopulation have been developed.

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Education and awareness strategies for preventing work injuries among young people are widely described in the scientific literature (Burke et al., 2004, Lavack et al., 2008). Safety training curricula targeted to youth tend to be developed on the assumption that their main cause of injury is attitude or behavior (Lavack et al., 2008; Power and Baqee, 2010). Such a focus on "safety culture" among young workers directed a school education movement in Quebec and other educational programs elsewhere in Canada and United States (Quebec Protocol of the ISSA, 2003; MELS, 2010; Power and Baqee, 2010). However, these approaches show mixed results (Burke et al., 2004; Rautiainen et al., 2008; Van der Molen et al., 2008).

Most current occupational health and safety (OHS) training and awareness approaches (Lavack et al., 2008; Ward et al., 2010; Power and Baqee, 2010) are based on a cognitive or a behavioral educational paradigm, which is oriented to shaping the new worker's attitude or behavior so that he or she will follow OHS rules. Those approaches focus on the trainer role and are unidirectional: knowledge exchanges from the trainer to the trainee. These programs emphasize training rather than learning strategies and appear to contradict recent developments in education sciences, which are oriented toward a competency-based pedagogy, involving in situ skill development, and based on activity theory (Vygostsky, 1962; Piaget, 1967; Jonnaert et al., 2007). According to this theory, learning derives from activity and is not a precursor to it. Thus, recent approaches promoted in education, based on a socio-constructivism paradigm, focus on the learner role.

In the work context, recent education theories stipulate that learning a new job takes place through the experience of actual activity in workplace settings (Lave and Wenger, 1991). Moreover, there is an emerging consensus that *learning* OHS skills (versus *being taught about* safe work techniques) is a useful way to prevent work injuries. Research priorities proposed recently by Canadian and American experts (Runyan et al., 2012) embrace the socioecological approach of understanding OHS learning process in their actual situation. They strongly suggest integrating injury prevention strategies within the organizational context. For instance, these experts pose the questions: What work conditions and practices of supervisors, co-workers and young workers contribute to safety? How do training, supervision, safety practices, and employer attitudes about young workers vary? What factors facilitate the successful movement of young people to jobs in school-to-work transition programs? They also proposed the development of scientific knowledge about the impact of social relationships at work on OHS and learning. The present study, focused on ergonomics of actual work activity, provides some answers to these questions.

The recent evolution in education science suggests that learning involves skills development through situated action and contact with other persons (Masciotra, 2005; Jonnaert et al., 2007). It is interesting to note that the field of Ergonomics, defined as the *scientific discipline concerned with the understanding of the interactions among humans and other elements of a system in order to optimize human well-being and overall system performance* (IEA definition), has similar theoretical grounds to those in education. In particular, the French approach to Ergonomics, widespread in Europe, Quebec and Latin America, derives its methods and framework from the same developmental theories as found in education, including Vygotsky, Leontiev and Piaget (Daniellou, 2005). Moreover, the field of Ergonomics is often applied to work injury prevention, not necessarily via training, but often by changing work conditions. Since the early 1990', scientists from the field of ergonomics of actual work activity have been concerned with using activity analysis methods to develop new training and learning approaches that consider learning content and also learning conditions (Montreuil and Teiger, 1996). In this paper, this ergonomics and education theoretical lens will be used to understand how young people learn to protect themselves from occupational injury in actual workplace situations. This will lead to a discussion of education paradigms (training vs. learning approaches) and to questions about the effectiveness of dominant training approaches in OHS.

2. Theoretical frame

As early as 1991, when the first symposium on *ergonomic analysis of work activity and training* was conducted at the International Ergonomics Association (IEA), ergonomists recognized that health is not independent from 'professional mastery' (Lacomblez et al., 2007). Guérin et al. (2007) and St-Vincent et al. (2011) propose an innovative approach to explain workplace learning through the '*work activity regulation model*'. This model considers the dynamic interaction between work activity, health and productivity. Work activity corresponds to the deployment of different working strategies based on constantly changing determinant factors and has an impact on health and performance. Determinant factors include external factors, including the conditions and means offered by the organization, tasks and work demands, and the social environment. Internal determinant factors correspond to individual characteristics such as fatigue, pain, experience, age, and gender. To balance performance and health outcomes, workers need adequate adjustment strategies and this requires a sufficient *margin of manoeuvre*. *Margin of manoeuvre* can be defined as the "space" available for self-regulatory process of a person engaged in an activity, or the capacity to self-regulate (St-Vincent et al., 2011). A limited *margin of manoeuvre* forces the worker to adopt safety strategies that can be costly for mental and physical health or productivity. For instance, if a worker has insufficient time to move many boxes, he may try to handle all the boxes in one move, even if this makes the load too heavy. Within the 'work activity regulation' framework, adequate in situ learning leads to workers with increased *margin of manoeuvre*.

This article presents findings from a larger ergonomics study that aimed to develop a tailored OHS training approach adapted to apprentices with learning difficulties who were enrolled in a semi-skilled high school level vocational training program. The objective of this article is to provide insight into the actual OHS learning process of adolescents during a 6–8 month internship. In this analysis, we focus on *auto* and *allo-confrontation* interviews (Mollo and Falzon, 2004) with apprentices enrolled in the program and experienced coworkers involved in the workplace training. Auto and allo-confrontation are methodological devices that allow participants to reflect on and explain their actual work activities, for instance, by discussing a video recording of their work activity (auto-confrontation) or that of others (allo-confrontation). This article further elaborates the activity regulation process model (St-Vincent et al., 2011) by focusing not just on consequences (health and productivity outcomes) but also on constraints and resources that shape these consequences. This article integrates an understanding of the activity regulation process described by St-Vincent et al. (2011) and aims to enrich this model.

3. Study context

In 2007, an educational reform in Quebec, Canada introduced a training program called *Training for a semi-skilled trade* (TST), was offered to 15 to 17 year old students experiencing academic failure or who are at risk of dropping out of high school. This program is offered in all Quebec school districts and the total number of students targeted is estimated at 15% of the total school population of 15–17 year old (MELS, 2009). This one year vocational training program provides job skills for a semi-skilled trade, such as kitchen

helper or stock handler jobs. During the training, students divide their time between remedial classes, workplace readiness courses, and a hands-on trade internship. Job and OHS skills are mostly developed in the workplace environment. This allows apprentices to achieve the minimal skills to transition from school to the labor market in a successful manner.

4. Materials and methods

4.1. Research setting

Data collection occurred over a full school year in two schools in socioeconomically different Quebec regions. Altogether, the schools provided vocational TST to 90 apprentices. The overall study design for the larger study included mixed methods, combining qualitative and quantitative data from several sources (interviews, documentary review, observations, and questionnaires). This current analysis of the larger study concentrates on auto and allo-confrontation interviews.

4.2. Participants and data collection

This analysis is based on matched samples of apprentices and experienced-coworkers who advised the apprentices in daily tasks within workplace placements. The term "experienced co-worker" (EC) used in this article includes a variety of oversight roles in different contexts (supervisor, formal mentor, co-worker) (Laberge et al., 2012). Nine apprentices from the larger study sample of 31 apprentices were followed by the research team. For these, in-depth data was gathered, involving videotaped observations at the workplace and 'auto-confrontation' interviews. Six of these apprentices were recruited from School 1; three from School 2. Most were male (8 men and 1 woman) and the nine apprentices covered six trades (inventory clerk, cook's assistant, printer's assistant, assistant welder, woodworker, and butcher's assistant). Five ECs involved in the hands-on training of these apprentices agreed to participate in 'allo-confrontation' interviews (about the work activities of the apprentices). They came from three different workplaces and were involved in the hands-on training of four apprentices training for three trades (inventory clerk, cook's assistant, and butcher's assistant) (see Fig. 1). The other apprentices' ECs were unable to participate for logistical reasons, such as location, and because of employer social relations.

Each apprentice was filmed during a complete day shift twice in their 8-month internship (start and end) to set the stage for the confrontation interviews. For the auto-confrontation interviews, a fifteen minute video was edited combining short sequences from the two waves of observation. The video sequences chosen illustrated (1) common tasks, (2) tasks that seemed difficult or problematic (such as awkward posture, quality rejection), (3) use of various equipment and (4) training situations. Two other types of data were presented to the participants: (1) shift chronicles (sequence and duration of workers' tasks during the two observation days) and (2) individual injury reports (including musculoskeletal symptoms). For the allo-confrontation interviews, the preparation differed slightly. A video was also prepared and included common apprentice tasks, situations that seemed difficult, and apprentice tool/equipment use. However, more emphasis was put on training situations involving ECs.

For both allo and auto-confrontation interviews, the participants were first asked to freely comment on the videos or the data shown. Afterward, they were asked to answer a set of open-ended questions. These questions were adapted for each interviewee to correspond to their own situations. However, all participant interviews addressed the following topics: nature of work tasks, difficulties encountered, teaching and learning processes, OHS hazards and injury experiences.

All data collection was conducted in French. Interview transcripts were translated to English by the lead author, and with the interpretive assistance of the English-language research team.

4.3. Data analysis

Fourteen confrontation interviews were audio-recorded and transcribed. Field notes were written to capture contextual information and emerging ideas. Data management was supported by Ethnograph 6.0, a software program that aids the researcher in the process of sorting and categorizing qualitative textual data. The analytic process followed four key steps: immersion in the data, coding, creation of categories, and explanation and interpretation of categories. The coding stage involved an interpretive approach with some pre-established domains of interest (such as learning skills, knowledge transmission, OHS issues) and some new domains based on emergent concepts in the data (such as discrepancies between what was asked and what was done) (Silverman, 2001). The analysis also involved a focus on discourse, such as what is meant by the systematic use of common expressions (such as '*common sense*'), and the narrative structures used by participants to describe the meaning of work experiences. To refine and combine categories into analytic themes, an iterative process involving techniques such

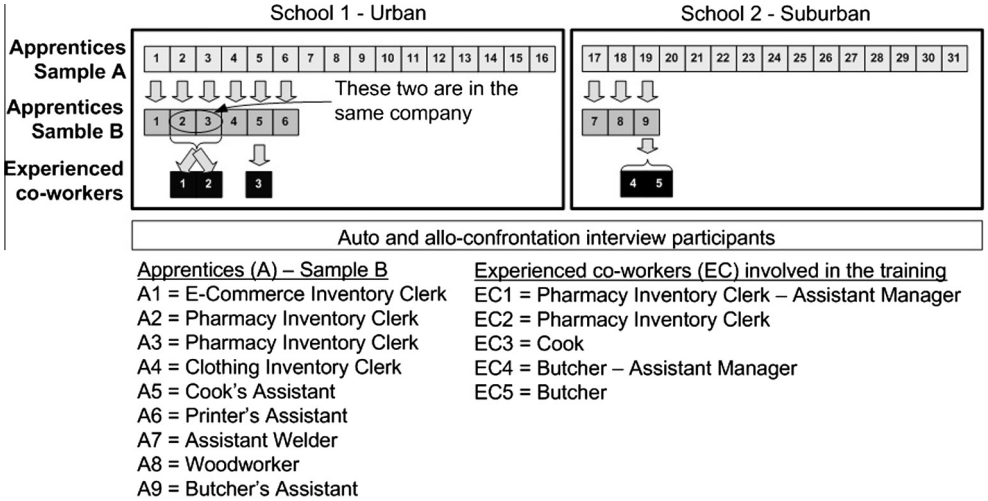

Fig. 1. Sample strategy and participants.

as constant comparison was used. The lead author, with the support of co-authors (each with strong backgrounds in qualitative research methods) identified conceptual categories that captured participants' work experiences.

4.4. Ethical considerations

The study received ethical approval from the Research Ethics Board of the University of Quebec at Montreal and two School Boards.

5. Results

This section describes analytic themes that illustrate the TST apprentice learning mechanisms in a workplace environment and in particular, the multidimensionality of learning OHS at work. A key finding is that it is difficult to distinguish OHS skills (e.g. knife skills to avoid cuts) from general job skills (e.g. cutting meat according to requirements). Therefore, the results include general observations about learning processes that, in turn, provide insight into OHS learning. More direct findings about OHS learning are also presented. The results are described in the following themes (which were each shared by at least four participants). First, teaching is not learning; second, the challenge of learning in situations; and third, the social dimension of learning in a workplace setting. For each section, particularly explicit quotes were chosen to illustrate findings.

5.1. Teaching is not learning

It became clear in the interviews that learning a semiskilled trade required more than being taught about tasks and operations. Teaching activities could occur without an obvious or immediate learning goal. Conversely, learning could also occur even if no specific training was offered. The following details from four apprentices and four ECs, across six trades, illustrate the underlying learning processes.

First, despite a widespread preconception that semi-skilled trades involve simple, easily reproduced tasks, we found that apprentices could not always easily and quickly repeat an operation demonstrated by a colleague.

> Apprentice 7 (A7): *The first day, they showed me how to weld and afterward, they let me alone to do the job.*
>
> Interviewer (Int): *How long did it take before you were able to do this task easily?*
>
> A7: *Hum... at least one month.*
>
> A6: *He showed me how to cut piles of paper, but it's hard to use it properly, it works with inches and I am used to measuring in centimeters, so it's complicated.*

For manual jobs such as these, motor skills development could require more than a few repetitions.

However, the ECs supposed that apprentices could normally reproduce an action, operation or gesture, if they were showed how to do it once.

> Int: *What do you need to tell him if you want him to be able to learn it properly?*
>
> Experienced Co-Worker (EC4): *Well, for sure you have to do it at least one time with him, that's basic. Afterward, you watch him doing it and if it's needed, you can give some advice. That's it basically.*
>
> *EC1: Facing is the easiest thing to learn. I mean, after two minutes of instruction, anyone can face.*

The co-workers all moderated their support via the construct of "common sense"; they did not instruct apprentices about issues that, to them, seemed obvious. However, for the apprentices, these issues and procedures were not clear. This need for instruction may be even truer for the youth in this sample, who had learning disabilities and lacked previous work experience.

> EC1: *Driving* [a buggy] *is easy. It's common sense, when it comes to learning, it's not like we had to really teach them.*

This construct of "common sense" was particularly strong in relation to OHS training. The interviews with apprentices revealed a lack of apprentice awareness about OHS hazards and a consequent trivialization.

> Int: *Do you think this smoke is toxic to breathe? Does it makes you cough?*
>
> *A7: No, it's just, when I blow my nose, it's black, but it's not dangerous*

This trivialization of OHS risk was reinforced by the experienced co-workers, who viewed the hazards as obvious and therefore not requiring discussion with apprentices.

> EC1: *A ladder is simple, everyone has seen a ladder before. It's nothing new [...]. To be perfectly honest, I don't think that was any formal training [...] It's common sense. I don't know if they used ladders in the past, but I used a ladder a couple of times before. It is a safety risk if you go high up.*

When experienced co-workers were confronted by video showing apprentices grappling inadequately with tasks that were 'obvious', they agreed that practice and repetition were necessary in order to gain dexterity and develop different techniques for the variable nature of tasks. During the learning period, the apprentices needed more time to perform operations, even if these operations seemed simple to the experienced co-workers.

> EC4: *You see there, he didn't catch the trick of keeping the tray empty and filling it with all the Styrofoam cups before putting meat in each cup; instead he was doing cups piece by piece.*

When viewing videos of apprentices, experienced co-workers observed hesitation and slow pace in their gestures. It illustrated an apprentice strategy that appeared fearful and cautious.

> EC4: *Here you see, he is nervous using the knife* [...]. *You see it in the speed and the way he manipulates.*

The interviews also showed that learning a new manual job involves motor-skills development (gesture, movement, fluidity) that are not intuitive. Knowing what is supposed to be done, and being able to do it, were two separate things (see Video 1).

> [The video shows a cook's helper apprentice awkwardly cutting an onion. This short film was selected because it quickly illustrates how motor skills learning can be challenging, even for a semi-skilled task].
>
> A8: [speaking about a strapping machine] *At the beginning of my internship, I experienced some difficulties, I was not used to it, but now things are going well, I know how to use it.*

The professional jargon is also crucial in the learning process. Although the language is important to know before learning operations, it was not systematically transmitted and was not always considered important by the different experienced co-workers.

> Int: *What do the boys call this?*
> A8: *Hum... good question, I don't know what to call this* [about a steel strapping tool].

Int*: Are there experienced workers who give less clear explanations than others?*
A7: Yes, [worker name] *(. . .) It's because he uses some word that I don't know what it means.*

All of these apprentices still had things to learn at the end of their internship. They reported being taught about how to do operations fairly early during the training, but they were mostly unable to answer questions about why these operations were required and had difficulty explaining their role in the production process, as well as the materials' properties, and the different ways of operating according to production variation. Without such knowledge, it is difficult for them to discriminate when and why one strategy should be preferred.

Int: [about a steel piece being cut]. *This piece will be a part of what?*

A7: *I don't know, I think that is for a client*

Int: *What damages the sharpness of your knife?*
A5: *I learned only last week* [at the end of the internship] *that when you move food with your knife like that* [showing a sliding movement] *it can damage it. The cook saw and told me: "Hey don't do that; it will ruin your knife*".

In all observed cases, the learning progression followed a peripheral participation model. That is, apprentices were mostly assigned to partial tasks before they were asked to do more comprehensive or global tasks. They learned some operations, but this barely provided a global perspective because the workers could not situate their own operations in the overall production flow. This limited the *margin of manoeuvre* because apprentices stayed inside the peripheral task borders and did not experience the full range of tasks. Even after several months, apprentices reported that they were not doing all the tasks for which they should have been trained.

Int.: *Are you sometimes assigned to the finishing?* [referring to a production stage normally done at his workplace]

A6: *No, they never showed me how to do it. I never had the chance to try it. It's hard; I think.*

Int: *Was he able to do Tartars alone at the end of the training?*
EC3: *(. . .) in general we prepared the mixture and then he was able to build up the plates.*

The interviews with experienced workers suggested that limiting apprentices to peripheral learning was in part due to reluctance from colleagues and supervisors to let them take on responsibilities. Several reasons were provided, such as a lack of trust or because apprentices are unpaid.

EC5: *Currently, he's doing more, we are asking him to do more stuff (. . .), but we are 3–4 butchers in the meat department; we want experience at the front line. For sure, he can't do as much as we do*.

Some experienced workers also tended to assign to apprentices boring or hard tasks that nobody else wanted to do.

EC3: *It's often the new workers who do that. It's the "youngest law"; they do boring tasks because other cook no longer wants to do it. That's it, it's simple. Everybody has to pass through it*.

In all, learning a new job, even one considered low-skilled, took time and was not always as easy as it looked. This suggests that training (showing a worker how to do something) is not learning (knowing how to do something and how to vary approaches under different conditions), and that resources other than training are needed to support learning.

5.2. The challenge of situated learning

Learning in a work situation involves facing diverse dynamic and iterative daily events. An actual work situation is often changing and unforeseeable and requires the development of nuanced approaches. While the apprentices reported experiencing diverse operational scenarios across the production variation, the experienced co-workers normally taught only one technique, which was generally their own preferred approach and applied to one typical case. However, in practice, apprentices must develop different techniques adapted to them and to the task variety. Examples provided in this section come from one apprentice and three ECs, in three trades (inventory clerk, butcher and cook's assistant).

A6: *It's a business where people come and always have different requests; orders change constantly* [. . .], *so you have to program different types of paper, colors [. . .], etc. Some clients are regular, so you learn what they need.*

Int: *What can you say to apprentices to support them with learning this task?*

EC2: *To follow a technique that helps them to work faster* [. . .] *to find a technique, no matter which one, that works well for them*

This dynamic sequencing of various work situations led to opportunistic or incidental learning, where unexpected or unusual situations became a source of learning. The richness of being exposed to a range of variability is, however, a double-edged sword. It can support the development of a range of adaptable knowledge and know-how, but it can also place young workers at risk of making poor decisions if not well supervised.

A6: *I noticed that it may be linked to electric current. . . when both printers work at the same time, I suspect that the electric power lowered* [in this case, to fix this problem, he manipulated a hot wire inside the machine and burnt his finger].

Incidental learning appeared to play an important role in OHS. Several apprentices reported that feeling pain or experiencing an injury, even minor, led them to develop new techniques or strategies to avoid reoccurrences. The experienced co-workers also admitted these injuries were unfortunately a frequent way to learn, and probably more efficient that being taught to take care.

EC5: *He cut his finger big time recently, and he needed 6 stiches. It's the way to learn, now he knows!*

Work conditions are also learning conditions for new workers. In some cases, poor or painful work conditions were barriers to learning. Examples included damaged tools, devices that were not user-friendly, workplace layout, physical environment, tasks and requirements (such as speed or quality), and physical and mental workload.

EC3: *I hate this machine*, *it's a real shit, it's cheap, too small, it doesn't work well. It's the third time we changed this machine in one year.*

EC5: There is always a way to reduce effort, but it remains that the job is the same. I often say, check the table, be sure that it's settled at the best height. Most pain symptoms are related to the table.

In an actual workplace setting, dealing with diversity, facing unexpected events, and coping with suboptimal work conditions can lead to the development of innovative skills that are different from those in formal training program stipulations (program competencies, evaluation criteria, requirements). The development of appropriate in situ responses corresponds to learning regulation

strategies and is required in order to enlarge the margin of manoeuvre.

5.3. The social dimension of learning

Learning in the workplace involves learning with other people. The social environment can be both a learning resource and a source of constraints. Apprentices reported that their experienced co-workers gave them useful information. All apprentices described several people as involved in their training. Having access to several informal trainers provided diversification in both teaching strategies and training content (details provided in this section come from one apprentice and three ECs, in three trades (inventory clerk, butcher and cook's assistant).

> EC4: [worker name] *is more the style "I'll stay beside you and I'll explain how to do it, but you will do it by yourself". For myself, I prefer to demonstrate first before asking him to do it.*
>
> Int: *Who's shown him how to build up a salad?*
>
> EC3: *Half me and half* [another worker]. *I explained the setting up and he showed him the preparation.*

Having access to instruction about different working techniques can be a resource for apprentices, and help them to develop diverse and adapted know-how across situations. However, in a multi trainer dynamic, the social environment may also be a source of constraint when the advice of one trainer is inconsistent with the advice of another, or when colleagues recommend tacitly, but collectively, a practice that goes against the rule.

Conversely, being left alone to do a task can be also both positive and negative. When an apprentice had to solve a problem without any help, this stimulated the development of innovative problem solving skills. However, the same situation could also be hazardous because mistakes could be made and safety could be compromised. One apprentice, during the observation day, had cut metal pieces of the wrong size for one hour before a colleague come to check his work and told him to scrap the entire order.

In this study, apprentices who were surrounded by other colleagues were best able to explain task processes and video data showed that they developed appropriate regulation strategies.

> Int: *Do you feel that you're able to give clients good advice?*
> A4: *Now yes. He taught me several things about shoes. He explained which ones are the best, for walking, for running, styles, fashion, vintage ones, etc.*

With respect to rules transgression, experienced co-workers explained that, in certain circumstances, they needed to break a work rule in order to complete a job properly, for instance within the quality standard frame, on time and with the means offered. These rule transgressions were not perceived as counter to established policies, but rather as a means to reconcile different work demands and regulate the workload. Moreover, sometimes a specific event could lead to two rules becoming contradictory. This kind of situation required a compromise strategy. With respect to OHS rules, the goal of strictly following rules was sometimes utopian. Both apprentices and experienced workers related situations where a rule had been adapted in order to be able to do a task properly and safely. Generally, experienced workers were able to develop proper strategies to negotiate production and safety, but these adaptions were not always obvious for young workers.

> EC1: *Basically what happened is that a delivery was coming in, and there were people in receiving* (collision risk). *Also, the ladder takes up a lot of space, and if they placed the ladder correctly, they would not be close enough to the product to get the product. So the method they used, they tilted the ladder on to the shelf itself. That is a little less stable, but it's stable enough since the weight of the ladder and the person would be pressed against the shelf. So, that's the best he could do in this situation.*

The auto and allo confrontation interviews consistently showed that learning OHS skills in an actual work situation did not just assist training and learning of safety rules. It also allowed for the integration of multiple contextual dimensions, and especially the social environment. As well, learning OHS skills could not be dissociated from other job skills. To be able to cope with inherent sources of constraint in a workplace, the apprentices needed to enlarge their margin of manoeuvre, and this depended on resources and means offered.

6. Discussion

The study addresses issues raised by an expert panel on young worker safety (Runyan et al., 2012) with respect to work (and learning) conditions, supervision, and social relations at work that can facilitate or hinder OHS learning. The analysis of nine apprentices in eight different trades has provided a portrait of training and learning processes, as well as social and cultural norms about health and safety in the workplace. This discussion will address three main themes highlighting some convergence and divergence between the findings and the current leading literature on youth and OHS: job tenure, in situ learning, and balance between inherent sources of constraint and resources in the workplace.

6.1. Youth, Job Tenure and OHS

Short job tenure predicts occupational injury more than age (Breslin and Smith, 2006). The present analysis expands understanding of the mechanisms of youth occupational injury around introduction, integration, and learning at work. Young apprentices can be left alone after only a couple of hours, or when doing hazardous tasks, such as welding. However, learning motor skills can be difficult, even if the task is considered simple. Although young workers are regularly labelled reckless (Lavack et al., 2008), the findings of this study challenge this notion. Young workers in this study did underestimate risks that were not obvious (such as toxic dust from welding), but when they were aware of a risk (such as cuts), they became careful.

This study's finding of mechanisms behind side-stepping rules as a strategy to meet work demands appears to be an original and new insight about OHS learning. This strategy was needed when working conditions led to situations that hindered observation of the normal rule or when two rules came into conflict. This strategy appears to be an inevitable part of the learning process of apprentices. Because EC's mastered side-stepping, this may explain why they have less accidents. This finding explains why most OHS training approaches, which are based on rules compliance and the development of a safe attitude, show low efficacy (Burke et al., 2004). Too often, risk-taking attitudes or rule transgression are considered something to be avoided, or punished, even when the deployment of these self-regulatory strategies can help to prevent injuries, as suggested in the *work activity regulation model*. Walker (2010) calls this kind of attitude a 'safety counterculture' that is perhaps less visible, but more active, than a formal safety climate. The intense deployment of training to shape safe attitudes and to punish deviant behavior could be reinvested in learning programs that consider the development of self-regulatory strategies as a normal process to gain experience and become competent.

Those findings support the growing socio-constructivist approach in education, which focuses on the learning rather that training to foster the development of competencies (Masciotra,

2005; Walker, 2010), and could overcome Burke et al. (2004) concern of low efficacy.

6.2. Learning in situation and OHS

The findings suggest that semi-skilled trades involve more skill than their generic title suggests. Absent in simulations, actual work situations provide unexpected events and variability, and these represent both work conditions and learning objects. Consequently, workplace learning processes need to involve learning not only to reproduce a work technique, but also to develop varied strategies to cope with unforeseen or atypical situations, i.e. enlarging the margin of manoeuvre (Vézina, 2001; Ouellet and Vézina, 2009; Laberge, 2011; Denis et al., 2013).

In the training program that was studied (TST), the young workers were first asked to do partial, peripheral tasks. This is a natural way to start learning, according to Lave and Wenger (1991), who describe the process by which a person who participates peripherally in a task can gradually learn knowledge and skills that lead eventually to the ability to perform the global task properly. However, in the present study, it appeared that apprentices never reached the global task, even at the end of their internship. This raises questions: (1) Is an 8-month internship sufficient to master the global task in semi-skilled trades? (2) Is the social environment sufficiently structured and organized to stimulate the transition from peripheral participation to the global task? (3) Are the working conditions in host companies sufficiently supportive of expansive learning?

These questions are partially answered by Gaudart et al. (2008), who suggest that when training and learning are not adequately coordinated or supervised, there is a risk of falling into an 'opportunistic' model of learning. This structure can prompt the blaming of individuals for failures and conceal recurrent organizational difficulties which hinder skills development.

6.3. The work activity regulation model

The *work activity regulation model,* developed in the fields of ergonomics and OHS, considers health status as an outcome of work activities (e.g. performance), and as dependent on a self-regulatory process: a constant adjustment of work strategies depending on margin of manoeuvre. We propose sustainable prevention of occupational injuries requires incorporation of the concept of balance between sources of constraints and resources (see Fig. 2). In this modified version of the *work activity regulation model,* the adjustment of resources to counterbalance sources of constraint at work is a realistic avenue for prevention, since it is not possible to eliminate all sources of constraint in a dynamic work environment. In this study, the population had unique characteristics. They were young workers with little or no experience of the labor market and diagnosed with learning difficulties. It is likely that they require extra resources to counterbalance their experience of learning disability sources of constraint.

This conception of learning based on equilibrium of work determinants relates to activity theory and the concept of expansive learning (Engeström, 2001). According to this theory, some environments stimulate learning more than others. Similar to Fuller and Unwin (2003), the findings have shown that workplaces have expansive (facilitating, enabling) *as well as* restrictive (barriers, disabling) elements. The challenge facing educators is learning and teaching to identify and evaluate these elements in varied situations because barriers cannot be completely removed in the context of work production. This is in line with Denis et al. (2013), whose study of OHS manual handling training, suggested that best working conditions are required to help workers develop competencies in real workplace situations.

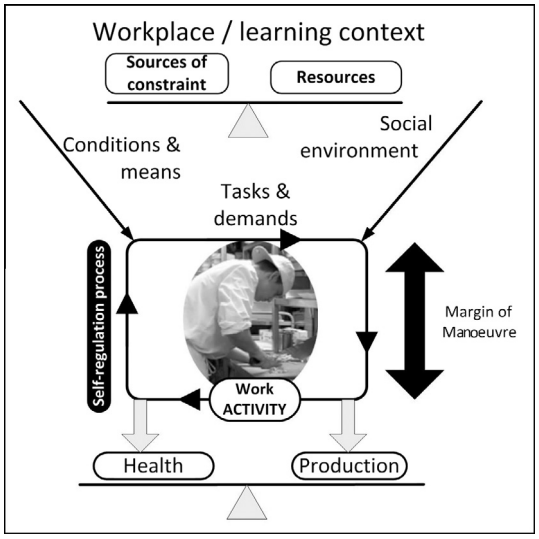

Fig. 2. Conceptual frame of the balance between sources of constraint and resources in the 'work activity regulation model'.

6.4. Scope and limitations

In this study, triangulated data was provided by allo-auto confrontation interviews; it comes first by collecting observation data in the workplace, and then, by interviewing apprentices and experienced co-workers about observation data. The analytical frame used the *work activity regulation model* that explicitly addresses the margins of manoeuvre. This analysis led to recommendations about bringing teaching and training closer to actual learning processes of young workers. Yet, because of the small sample and the large number of variables, our findings are rather directions for further development and research than immediately applicable prescriptions. For instance, the study showed how hands-on training occurs in practice in actual workplaces. The results prompt questioning of current approaches in OHS training based on a behavioral paradigm in education, but this study cannot recommend what would be the best training program. Further studies using constructivist models of 'learning in situations' are needed.

7. Conclusion

Currently, most prevention approaches geared to improving OHS among young workers derive from teaching paradigms (e.g. lectures, awareness campaigns, behavioral modeling) rather than learning paradigms (e.g. situated learning, community of practice), and most are disconnected from the work context (Burke et al., 2004). This study supports earlier recommendations (Runyan et al. 2012) on the relevance of a socioecological approach to approach OHS learning process and suggests the need to integrate injury prevention strategies within organizational contexts. For instance, the findings suggest the need to explicitly address strategies for rule transgression and self-regulatory processes in teaching, so that apprentices can engage in more efficient learning processes in workplace.

The use of an ergonomics approach allowed the merging of two research topics that are rarely found together in the literature: the potential of the socio-ecological paradigm in education and the development of original interventions to prevent occupational injuries among young workers. The intersection of these two topics provides new perspectives in both the improvement of vocational training programs and primary prevention intervention in OHS programs targeting youth, a population considered vulnerable

due to work conditions and job inexperience. This analysis also suggests improvements to the *work activity regulation model*, relating not only to the balance of consequences (health and productivity) but also to a necessary equilibrium in work determinants adapted to the person (balance between sources of constraint and resources), which is also the ultimate goal of ergonomic interventions. This OHS learning model based on activity theory is useful for understanding tension in a work organization and for elaborating sustainable solutions that promote the development of work skills including their OHS component.

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Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.ssci.2014.04.012.

References

Breslin, F.C., Smith, P., 2005. Age-related differences in work injuries: a multivariate, population-based study. Am. J. Ind. Med. 48 (1), 50–56.
Breslin, F.C., Smith, P., 2006. Trial by fire: a multivariate examination of the relationship between job tenure and work injuries. Occup. Environ. Med. 63 (1), 27–32.
Breslin, F.C., Day, D., Tompa, E., Irvin, E., Bhattacharyya, S., Clarke, J., Wang, A., 2007. Non agricultural work injuries among youth. A systematic review. Am. J. Prev. Med. 21 (2), 151–162.
Breslin, F.C., 2008. Educational status and work injury among young people. Can. J. Public Health 99 (2), 121–124.
Breslin, F.C., Pole, J.D., 2009. Work injury risk among young people with learning disabilities and attention-deficit/hyperactivity disorder in Canada. Am. J. Public Health 99 (8), 1423–1430.
Breslin, F.C., Smith, P., 2010. A commentary on the unique developmental considerations of youth. Int. J. Occup. Environ. Health 16 (2), 225–229.
Burke, M.J., Sarpy, S.A., Smith-Crowe, K., Chan-Serafin, S., Salvador, R.O., Islam, G., 2004. Relative effectiveness of worker safety and health training methods. Am. J. Public Health 96 (2), 315–324.
CSST. 2012. Portrait des jeunes travailleurs de 24 ans et moins. Année 2011. Montréal: CSST.
Daniellou, F., 2005. The French-speaking ergonomists' approach to work activity: cross-influences of field intervention and conceptual models. Theor. Issues Ergon. Sci. 6 (5), 409–427.
Denis, D., Lortie, M., St-Vincent, M., Gonella, M., Plamondon, A., Delisle, A., Tardif, J., 2013. Participatory Training in Manual Handling – Theoretical Foundations and Proposed Approach. Montréal: IRSST, Report R-784.
Engeström, Y., 2001. Expansive learning at work: toward an activity theoretical reconceptualization. J. Educ. Work 14 (1), 133–156.
Ethnograph 6.0. Qualis Research, Colorado Springs. <www.qualisresearch.com>.
Fuller, A., Unwin, L., 2003. Learning as apprentices in the contemporary UK workplace: creating and managing expansive and restrictive participation. J. Educ. Work 16 (4), 407–426.
Guérin, F., Laville, A., Daniellou, F., Duraffourg, J., Kerguelen, A., 2007. Understanding and Transforming Work. The Practice of Ergonomics. ANACT, Paris, France.
Gaudart, C., Delgoulet, C., Chassaing, K., 2008. La fidélisation de nouveaux dans une entreprise du BTP: Approche ergonomique des enjeux et des déterminants. Activités 5 (2), <www.activites.org/v5n2/v5n2.pdf>.
International Social Security Association (ISSA). 2003. Quebec City Protocol for the Integration of Occupational Health And Safety Competencies Into Vocational And Technical Education. Quebec: ISSA.
Jonnaert, P., Masciotra, D., Barrette, J., Morel, D., Mane, Y., 2007. Curriculum change and competency-based approaches: a worldwide perspective. From competence in the curriculum to competence in action. Prospects 37 (2), 187–203.
Laberge, M., Ledoux, E., 2011. Occupational health and safety issues affecting young workers: a literature review. Work 39 (3), 215–232.
Laberge, M., 2011. Accueil et intégration sécuritaire et compétente en emploi des élèves inscrits à la formation menant à un métier semi-spécialisé du parcours de formation axée sur l'emploi. Ph.D. Dissertation, Montréal: UQAM.
Laberge, M., Vézina, N., Calvet, B., Lévesque, S., Vézina-Nadon, L., 2012. Supervision of apprentices in semiskilled trades: program stipulations and workplace realities. Relat. Indus./Indus. Relat. 67 (2), 199–221.
Lacomblez, M., Bellemare, M., Chatigny, C., Delgoulet, C., Trudel, L., Vasconcelos, R., 2007. Ergonomics analysis of work activity and training: basic paradigm, evolutions and challenges. In: Pikaar, R.N., Koningsveld, E., Settels, P. (Eds.), Meeting Diversity in Ergonomics. Elsevier, Oxford, UK.
Lavack, A.M., Magnuson, S.L., Deshpande, S., Basil, D.Z., Basil, M.D., Mintz, J.H., 2008. Enhancing occupational health and safety in young workers: the role of social marketing. Int. J. Nonprof. Volunt. Sec. Market. 13 (3), 193–204.
Lave, J., Wenger, E., 1991. Situated Learning: Legitimate Peripherical Participation. Cambridge University Press, New York.
Masciotra, D., 2005. Le socioconstructivisme, un cadre de référence pour un curriculum par compétences. Curriculum de la formation générale de base. Québec: MELS.
Mollo, V., Falzon, P., 2004. Auto- and allo-confrontation as tools for reflective activities. Appl. Ergon. 35 (6), 531–540.
Montreuil, S., Teiger, C., 1996. The foundations and contributions of ergonomics work analysis in training programmes. Saf. Sci. 23 (3), 81–95 (Special Issue, The ergonomist, the Trainer and Ocupational Health and Safety).
Ouellet, S., Vézina, N., 2009. Professional knowledge and MSD prevention: portrait of their transmission during training and the intervention perspective. PISTES 11 (2), <www.pistes.uqam.ca/v11n2/pdf/v11n2a4.pdf>.
Piaget, J., 1967. Biologie et connaissance. Essai sur les relations entre les régulations organiques et les processus cognitifs. Gallimard, Paris.
Power, N., Baqee, S., 2010. Constructing a 'culture of safety': an examination of the assumptions embedded in occupational safety and health curricula delivered to high school students and fish harvesters in Newfoundland and Labrador, Canada. Policy Pract. Heal. Saf. 8 (1), 5–23.
Québec, ministère de l'Éducation, du Loisir et du Sport (MELS). 2009. Les EHDAA. Évolution des effectifs et cheminement scolaire à l'école publique. Publication du gouvernement du Québec.
Québec, ministère de l'Éducation, du Loisir et du Sport (MELS). 2010. Tiens ton bout... Préviens les dangers. Guide de l'enseignant. Situation d'apprentissage et d'évaluation. <www.mels.gouv.qc.ca/sst/admin/index.asp?page=axeEmploi>.
Rautiainen, R.H., Lehtola, M.M., Day, L.M., Schonstein, E., Suutarinen, J., Salminen, S., Verbeek, J., 2008. Interventions for preventing injuries in the agricultural industry. Cochrane Database Syst. Rev. 2.
Runyan, C.W., Lewko, J., Rauscher, K., 2012. Setting an agenda for advancing young worker safety in the US and Canada. Public Health Rep. 127 (3), 246–252.
Silverman, D., 2001. Interpreting Qualitative Data: Methods for Analysing Talk, Text and Interaction. Sage, Thousand Oaks.
Sorock, G.S., Lombardi, D.A., Hauser, R.B., Eisen, E.A., Herrick, R.F., Mittleman, M.A., 2001. A case-crossover study of occupational traumatic hand injury: methods and initial findings. Am. J. Ind. Med. 39 (2), 171–179.
St-Vincent, M., Vézina, N., Bellemare, M., Denis, D., Ledoux, E., Imbeau, D., Lapierre, J., 2011. L'intervention en ergonomie. Éditions Multi-Mondes, Québec.
Vygostsky, L.S., 1962. Thought and Language. MIT Press, Cambridge, Mass.
Van der Molen, H.F., Lehtola, M.M., Lappalainen, J., Hoonakker, P.L.T., Hsiao, H., Haslam, R., Hale, A.R., Verbeek, J., 2008. Interventions for preventing injuries in the construction industry. Cochrane Database Syst. Rev. 2.
Vézina, N., 2001. La pratique de l'ergonomie face aux TMS: ouverture à l'interdisciplinarité. In: Proceedings of SELF-ACE Conference. Montréal, October 3–5, 2001.
Walker, G.H., 2010. A safety counterculture challenge to a "safety climate". Saf. Sci. 48 (3), 333–341.
Ward, J.A., De Castro, A.B., Tsai, J.H., Linker, D., Hildahl, L., Miller, M.E., 2010. An injury prevention strategy for teen restaurant workers. AAOHN J. 58 (2), 57–65.