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1. Issue

1 In companies, experienced workers who are recognized by their peers for their know-how often receive the mandate to train new workers. While the transmission of knowledge from experts to novices is an old practice, it seems that the worker-instructor has become, in the last few years, a key actor in companies. According to Bélanger et al. (2004), a systematization and intensification of training activities on hiring is observed. A worker who receives only a few instructions before being integrated into the workstation would be seen less often. Thus, worker-instructors receive the mandate to transmit the knowledge that they themselves have received from other workers or that they have developed with practice. This knowledge built through actual experience brings cognitive aptitudes into play (Chevallier and Chiva, 1991) in order to integrate it and organize it in relation to oneself and the technical, organizational and social context, as well as perceptive-motor capacities related to the detection and processing of information useful for performing the task (Chassaing, 2006; Gaudart, 1996). These capacities developed over time allow experienced workers to anticipate, correct, adjust and decide on the best

movements to perform at each step in the task (Bril and Roux, 2002). They also enable them to protect their health and prevent musculoskeletal disorders (MSDs) (Denis et al., 2007; Chassaing, 2006; Ouellet et al., 2003; Chatigny, 2001; Authier, 1996). It would therefore be desirable to see workers with this knowledge pass it on to apprentices, from the standpoint of promoting MSD prevention through training. But what knowledge are the worker-instructors capable of transmitting? Publications have already described workers' difficulty in formalizing their ways of doing things when they are questioned on this subject (Teiger, 1996; Daniellou and Garrigou, 1995). This difficulty could be explained by two factors: 1- the fact that numerous job knowledge elements have become unconscious over time due to automatic actions developed in the activity (Leplat, 2005); and 2- the fact that these workers have not necessarily had the opportunity to formalize their knowledge in order to make it more easily transmittable (Vézina et al., 1999). It would be advantageous if knowledge became unconscious, since it would offer workers the cerebral availability necessary for planning what is coming or for anticipating critical situations (Leplat, 2005). Bellier (2002, p. 49) agrees by mentioning that,

> "Competency in fact consists of no longer knowing why and how you are competent! This automation process alone guarantees a good part of the efficiency and performance. It frees the mind from the method and leaves room for processing other more contingent information. As a result, the expert does not know how to explain what he is an expert at." (free translation)

2 It is also important to mention that these workers are not always prepared to pass on knowledge to other people.

3 Furthermore, the desire to study the transmission of knowledge by worker-instructors raises several methodological questions. What analysis must we do of the content to be transmitted to the apprentices (Leplat, 2002)? From this content to be transmitted, how do we analyze what is transmitted? And finally, from the standpoint of promoting MSD prevention, what types of knowledge must be the subject of the analysis of the content transmitted? To initiate reflection on these questions, it seemed interesting to us to present the meaning that Sigaut (1991, p. 42) gave to the concept of transmission. For this author, the act of learning is individual and "*Transmitting knowledge is to place someone in the best possible conditions so that he can acquire this knowledge himself, using his own sensory and mental resources.*" (free translation) Transmission therefore has the objective of promoting the appropriation, by the apprentice, of knowledge that enables him to construct his own know-how. As a result, we assume that this appropriation involves a process that will lead the apprentice to understand the knowledge elements transmitted and to make associations between these different knowledge elements in such a way as to mobilize them at the appropriate time to achieve his objectives in relation to the situations. We can therefore assume that it is important not only to transmit to the apprentices the "what to do" but also the "why" and the "how" to do it. On this subject, Bellier (2002, p. 48) mentions that:

> "Analysis of the content elements to be transmitted must go much farther than the simple mechanics of physical, concrete or abstract movements. The understanding of the underlying method, the "way of going about it" must be integrated right away."(free translation)

4 This article results from a study carried out in the context of a doctoral project with a dual purpose: 1-to construct new knowledge elements relating to MSD prevention and to training in companies; and 2-to respond to a company's request by developing the content of a training manual and by facilitating the implementation of new methods for

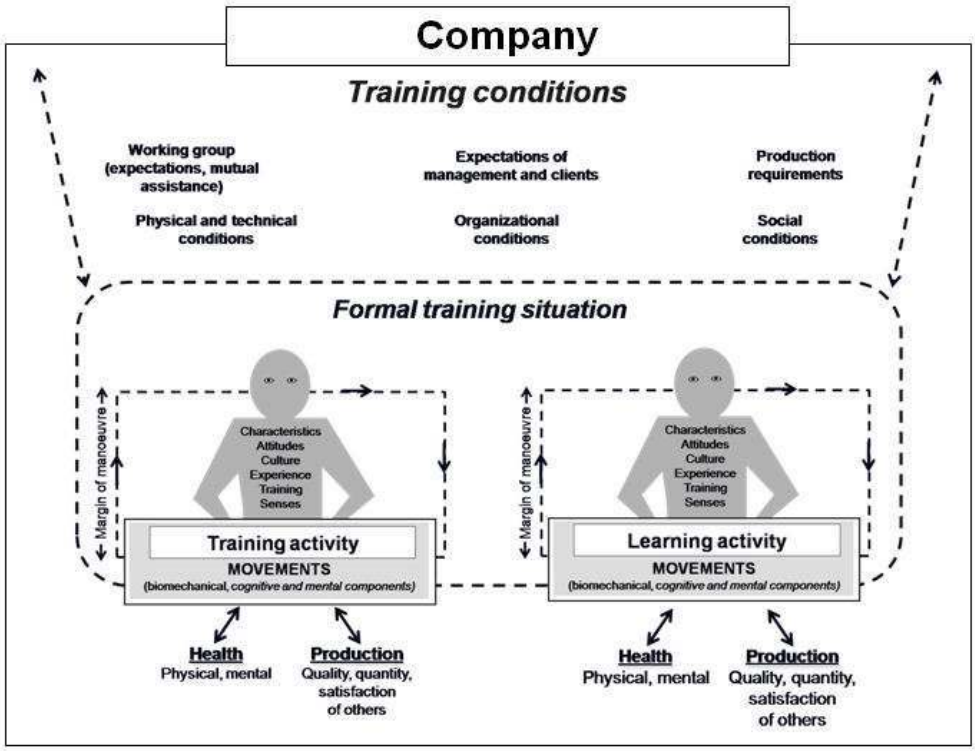
organizing training and learning conditions. The article aims to: 1- present a theoretical framework and a procedure that made it possible to analyze the types of knowledge elements transmitted by worker-instructors to apprentices in the context of training in meat cutting in a company in the agroprocessing industry; 2- discuss the contribution and limitations of the results of this analysis in the development of training in a company.

2. Theoretical framework

5 In this article, we will discuss the question of knowledge element transmission using the ergonomic approach resulting from the activity analysis approach. Both the training activity and the learning activity will be considered in a systemic way by taking into account the individual (instructor or apprentice) with his specific characteristics, his status, his culture, his experience, his representations, and by attempting to identify the determinants related to the company, with its rules of operation, its programs and the conditions of work performance and training of new workers. Figure 1 presents an explanatory model of the training dynamics in companies, which was inspired by other ergonomic models (Guérin et al., 2006; Bourgeois et al., 2006; Chatigny, 2001; Vézina, 2001). This model, which guided the formulation of the goals and the construction of the methodology, is an attempt to integrate several elements mentioned in the literature review that are likely to influence and/or be influenced by the activity carried out by the instructor as well as by the apprentice.

6 Thus, we find in this model a worker with his own characteristics (gender, age, training, experience, culture, etc.) who received the mandate to transmit his knowledge to one or more apprentices (with their characteristics) under given conditions that may or may not be different from the working conditions. These conditions include the physical conditions (environment – layout and areas), technical conditions (machines and tools), organizational conditions (schedules, teamwork, time organization, etc.) and social conditions (mutual assistance, coworkers' expectations, recognition of his role as instructor, etc.).

Figure 1. Model presenting the determining factors in the training and learning activity



7 In this diagram, we use two-directional arrows to show that these conditions influence the activity of the instructor and of the apprentice, but can also be influenced by these individuals during their activity. Thus, the instructor can use the resources allocated to him but also transform some of these resources in order to facilitate the acquisition and development of know-how by the apprentices (Chatigny, 2001). For example, the instructor can make a mark on the knife blade to provide a cue for the apprentice as to the appropriate depth that this blade must enter the piece of meat. He can also use strategies to modulate the constraints imposed by the context, as for example ending the apprentice's cycle if the latter is behind schedule. The training conditions will have an impact on the instructor as well as on the apprentice because they will affect the way that the instructor will carry out his training activity and the level of difficulty encountered by the apprentice in his learning. Thus, the instructor's activity is determined by the conditions offered to him and these will be more or less favourable to the development of strategies that allow him a certain margin of manoeuvre. The magnitude of the available margin of manoeuvre built by the instructor determines not only how he can fulfill his employer's expectations and meet his own objectives, but also how he can implement strategies in order to allow the apprentice to develop his own margin of manoeuvre to achieve his own objectives. By considering the overall training situation with the different components of the context, the ergonomic analysis makes it possible to identify what may constitute obstacles to the achievement of the instructor's objectives but also to the apprentice's learning.

8 Furthermore, we should mention that in the workplace studied, as is often the case in the agroprocessing sector, the worker chosen to be an instructor does not receive instructor's training, nor does he have a formalized training content which he could use as a basis for training new employees. As a result, the instructor passes on the knowledge that he has

acquired and developed in practice and that he is able to verbalize. The level of transmission of the knowledge can therefore depend on the capacity of the worker-instructor to reflect on his practice and his abilities as a communicator. In Figure 2, we present a model showing the process of transmission of knowledge by the instructor as well as the development of practical knowledge by the apprentice. First, it is important to emphasize that we use in this model a definition of the concept of "know-how" and a typology of knowledge elements that were presented in a previous article. We then explained that this definition and this typology originate from field data rather than from the amalgamation of different theories (Ouellet and Vézina, 2008). For the purposes of this article, we will give a few of these definitions. Thus, we define the concept of "know-how" as being

> "the capacity of an individual to mobilize in his activity a set of knowledge elements that allow him to reach an objective."

9 With experience and practice, the individual develops, over time, several different know-how elements that enable him to meet the production requirements and/or to protect his health. Training should promote the development of this know-how by the apprentice, mainly through the transmitted knowledge, which he can use and/or adapt. We must also emphasize that in ergonomics, we are greatly interested in the know-how that allows experienced workers to protect themselves. Although in the literature it is a question of "preventive skills" (Chatigny and Vézina, 2004; Garrigou et al. 2004; Vidal-Gomel, 2002; Cru and Dejours, 1983), we have chosen to talk about

> "efficient know-how" as being "the capacity of an individual to mobilize in his activity a set of knowledge elements that allow him to fulfill an objective targeting both production and the protection of his health and that of others."

10 In these "efficient know-how elements," we find a "*production*" aspect and a "*preventive*" aspect, as for example,

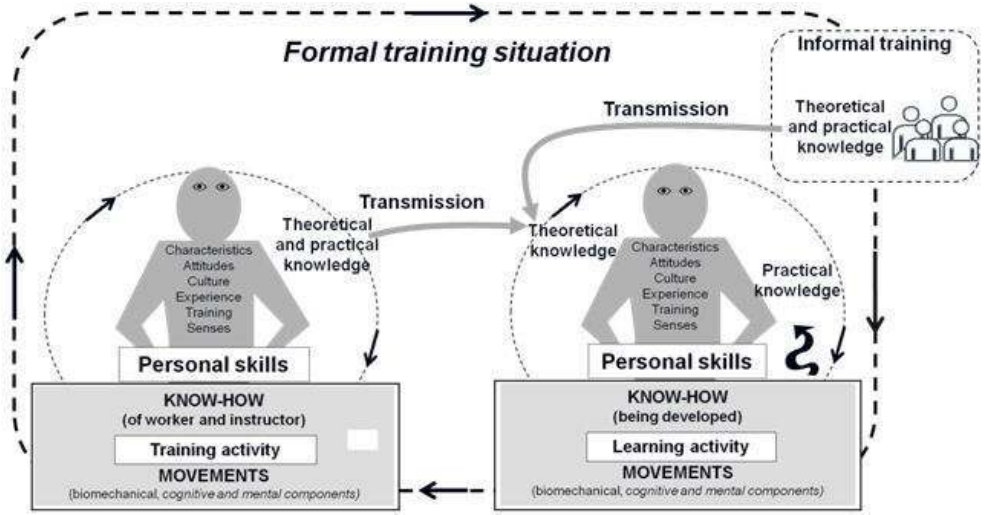
> "removing the bone by having the knife stroke at the right place (production aspect) and by positioning the piece of meat to reduce postural constraints (preventive aspect)."

11 According to our model, a know-how element cannot be transmitted, but is instead constructed through practice. What can be transmitted is a set of knowledge elements that can be mobilized in applying this know-how. In the previous article, we were able to show that for the application of a single efficient know-how element, several different knowledge elements can be mobilized, and that there exists a hierarchy in these mobilized knowledge elements. This hierarchy is such that, to protect themselves, workers must develop certain know-how elements associated with the "production" aspect.

12 Regarding the knowledge elements mobilized in the know-how element, we proposed a typology that includes theoretical knowledge and practical knowledge, the concept of "knowledge element" being considered as knowledge acquired through training and/or practice. Theoretical knowledge elements are specialized knowledge elements relating to a specific field that are essentially acquired through formal or informal training (Figure 2). The instructor can transmit them verbally to the apprentices during formal training or through other people (coworkers, for example). In this latter case, it would be informal training. This aspect of training has not been documented in our study. Theoretical knowledge elements can also be acquired through a personal process, for example by reading manuals or by observing movements of the instructor or other people. In these

two respective cases, Girin (2005) refers to methods of transmission by "*internalization*" and by "socialization." In this article, we will focus on what the instructor transmits verbally during formal training.

Figure 2. Model of the knowledge transmission process focusing on what the instructor contributes



13 As for "*practical knowledge,*" this is the knowledge that is developed by practice, therefore by doing the work. The worker thus develops tricks, cues, techniques and strategies. With experienced workers, this knowledge, originating from a cognitive activity comparing various aspects of the context, allows them to better assess and decide on the most appropriate movements in relation to the situations. This practical knowledge serves to complete as well as to relativize the "*theoretical knowledge*." It can itself become "theoretical knowledge" when it is formalized and integrated into a training content that will be transmitted to apprentices so that they more easily develop their own practical knowledge in their learning activity and thus improve their know-how.

14 The objective during the conception of training would therefore be to promote the transmission of knowledge by first encouraging the worker-instructors to verbalize their practical knowledge (therefore developed in their practice) to make it transmittable (therefore becoming theoretical knowledge), a step that was described in Ouellet and Vézina (2008). However, the fact of transmitting this knowledge to apprentices does not guarantee its complete integration and the execution of the same movements (Clot, 2002). The apprentice will always have to develop his own practical knowledge because he will have to appropriate the theoretical knowledge, that is, adapt it to his personal characteristics. This is what we wanted to show in Figure 2 by the arrow from the apprentice's learning activity to the practical knowledge. The aim of transmission is therefore the appropriation by apprentices of the knowledge communicated by worker-instructors that will allow them to be able to act in relation to the contexts.

15 Moreover, there are also the personal skills that result from the relationship between a set of factors related to the person. For "*personal skills,*" we adopted the definition given by De Ketele (cited by Barbier and Galatanu, 2004, p. 59), who presents this knowledge as being "*the activities by which a person shows not only how he understands himself ("self concept"), others, situations, and life in general, but also how he acts and reacts.*" (free translation) The person builds his personal skills by experience from his internal resources (characteristics and memory of his actual experiences) as well as from what he will be

able to receive from and perceive from the group. Just like knowledge, personal skills cannot be transmitted. However, principles or values to be favoured for performing the task can be transmittable, as for example the principle of "*paying attention*" or the tricks for improving concentration. From what is transmitted, the apprentice will try to pay attention to what he does by attempting to integrate these tricks in relation to his own characteristics, capacities, actual experience and perception of the level of attention required. The objective in this study is not to describe the knowledge elements necessary for developing the personal skill elements of meat deboners since we consider that behaviour modification is not the realm of ergonomists. Nonetheless, we could not disregard the concept of personal skills in our model because, on the one hand, the ergonomic approach favoured in this project considers the person performing the activity, with his experience and his characteristics, and on the other hand because, in phase 1, worker-instructors verbalized principles related to "how to be" in order to do deboning successfully.

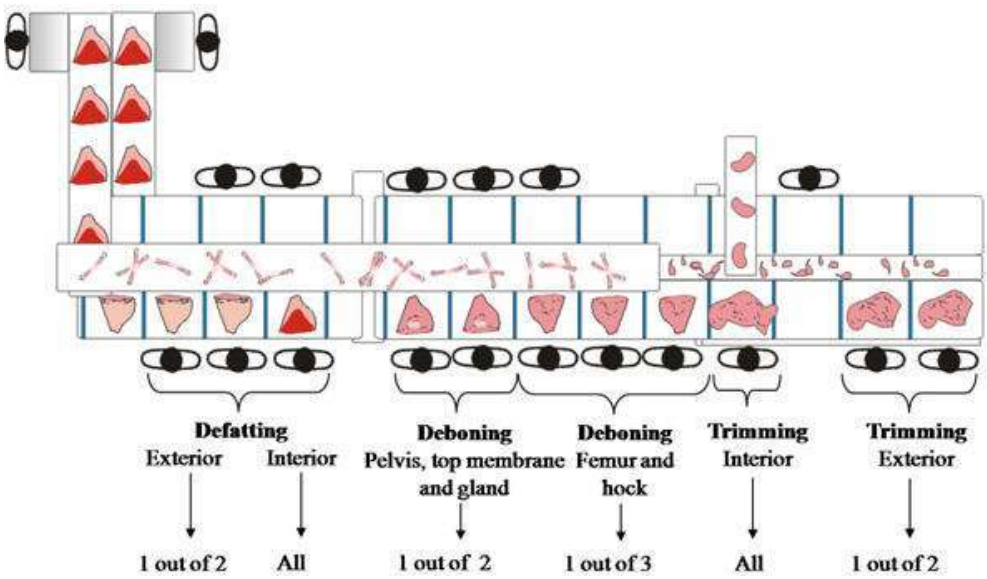
16 During phase 1 in this study, the knowledge received and developed by a group of experienced workers was put into words (Ouellet and Vézina, 2008) by means of individual and group interviews with the experienced workers. These workers included the two instructors. The knowledge elements identified during this phase 1 were used to analyze the training content transmitted to apprentices during phase 2, which is the subject of this article. We should mention that in the context of this article, our attention is on efficient knowledge, therefore the know-how that combines both a production objective and a health protection objective. The specific objectives targeted in this article are:

1. To verify whether the knowledge elements identified in phase 1 for each worker-instructor are all transmitted verbally to the apprentices during training (phase 2), particularly the health protection knowledge elements;
2. To verify whether knowledge elements not identified using the ergonomic approach are transmitted to the apprentices in a training context; and
3. To verify whether the transmitted knowledge elements are expressed in terms of "what to do" and/or "why do it."

3. Context

17 This study was carried out in a company with a total of 350 male and female production employees of which 25, all males, do the defatting and deboning of pork hams. The processing of pork hams is done in sequences on a mobile production line with a general pace corresponding to the arrival of a ham every 18 seconds (Figure 3). The workers rotate through all the jobs, which forces them to know how to debone as well as defat the pieces of meat. This study, carried out in the context of a doctorate, follows up on a request by the company, which wanted to obtain training content for the two tasks and also to be guided in how they organized their training. For the purposes of this article, only the deboning task was considered. This task has two sequences, namely one sequence that consists of removing the bone from the hip, a sequence called "pelvis" (removal of pelvis, membrane and gland) and a second that consists of removing the two bones of the leg connected by a joint (femur and hock), sequence called "femur."

Figure 3. Diagram of the organization of the production line for pork ham processing



18 This latter sequence was the subject of our study. Three meat deboners at a time occupy the "femur" sequence. Each one processes one piece of meat out of three (Figure 3), which gives them 54 seconds to perform one sequence that includes the following operations: 1- placing the piece of meat; 2- deboning the piece of meat (removing the bone); 3- doing the finishing of the inside piece; 4- putting the piece of meat back; and 5- sharpening the knife.

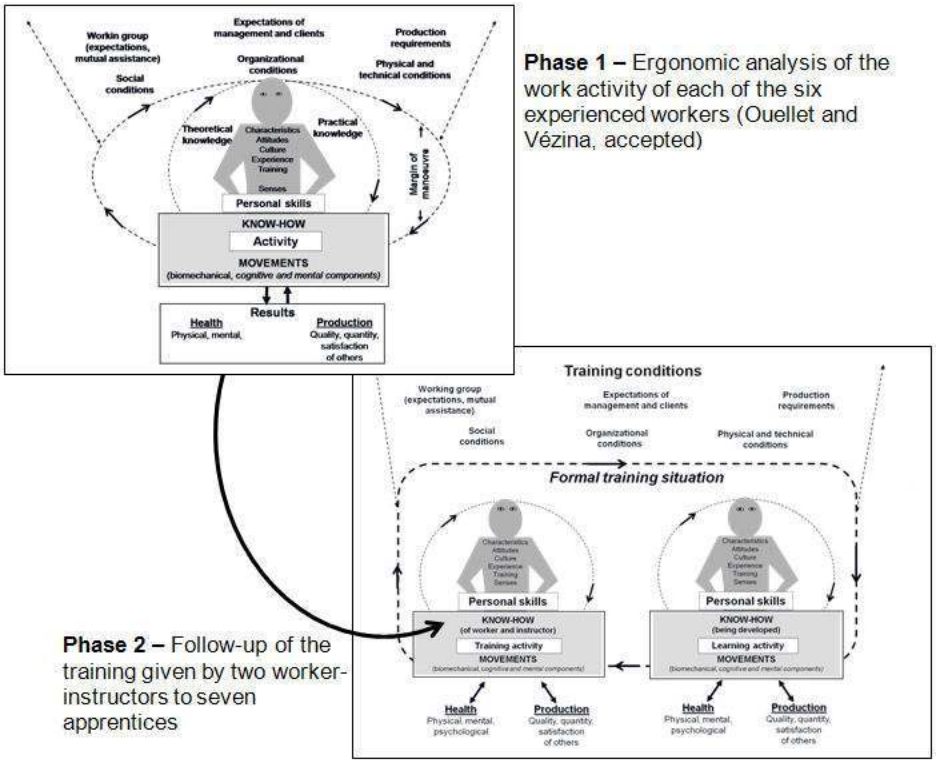
19 We should mention that in this company, the deboning and defatting workstations can only be occupied by employees with several years of experience because this job is one in which the workers are the best paid. Therefore, when manpower is required, the position is posted internally and is given to the applicant with the most seniority. When the candidate is chosen, he must take eight weeks of training, namely six weeks of deboning and two weeks of defatting. The apprentices begin their apprenticeship in deboning on a stationary workstation located outside the production line. Subsequently (after 4 to 5 days), apprenticeship on a mobile conveyor is introduced with a pace that gradually increases in relation to the level of learning reached. Finally, approximately two weeks before the end of the six weeks of training in deboning, the apprentices are gradually integrated into the normal production line. It is at the end of training that the candidate is officially confirmed in the position.

4. Methodology

20 In order to situate the methodology and results that will be presented, we believe it is important to describe briefly the complete approach that was followed in the study (Figure 4). This approach had two main phases, namely an initial phase that consisted of doing the ergonomic analysis of the work activity of a group of experienced workers that included the two deboning instructors (Ouellet and Vézina, 2008), and a second phase that consisted, using the ergonomic approach, of following up on the training given by these worker-instructors.

21 We should mention that it was during the initial phase that the know-how elements were identified and that the knowledge elements mobilized by each worker-instructor were put into words by means of individual and group interviews with a group of six experienced workers that included the instructors. In the following sections, we present the methodological aspects of the second phase, which is the subject of this article.

Figure 4. Diagram of the two main phases of the study



4.1 Characteristics of the worker-instructors

22 In this company, as in many others, the instructors are experienced workers recognized by their peers for their ability to meet the production requirements while maintaining their health. Table 1 presents the characteristics of the two worker-instructors. One fact to be emphasized is that even though instructor 1 had fewer years of experience in the company (6.5 years), he had several years of deboning experience in other companies in the agroprocessing sector. As for instructor 2, he had worked in a completely different sector before working in the company. In order to maintain the confidentiality of the results associated with the instructors, we will use the letters D and H to identify them in the sections below.

Table 1. Characteristics of the deboning instructors

	Age	Height	Dominant hand	Seniority in plant	Seniority at deboning workstation	Other jobs meat sector

Instructor 1	42	1m68 (5'6")	Right	6.5 years	6.5 years	Slaughterhouse/ processing 20 years/ deboning
Instructor 2	34	1m73 (5'8")	Right	12 years	8 years	None

4.2 Characteristics of the apprentices

23 A total of seven apprentices followed training in the deboning and defatting of pork hams, with three in the first group, two in the second, and two in the third group. Table 2 presents the characteristics of the seven apprentices. Six of the seven apprentices were right-handed and one was left-handed. Their average age was 39.7± 6.7 years and they had on average 9.6 ± 1.3 years of experience in the company.

Table 2. Characteristics of the apprentices

	Apprentice #	Age (years)	Seniority in plant	Deboning experience
Group 1	Apprentice 1	40	9 years	Little experience*
	Apprentice 2	45	10 years	Little experience*
	Apprentice 3	36	10 years	None
Group 2	Apprentice 4	35	9 years	Little experience*
	Apprentice 5	51	8 years	None
Group 3	Apprentice 6	40	12 years	None
	Apprentice 7	31	9 years	None

*** THE EXPERIENCE WAS QUALIFIED AS LITTLE EXPERIENCE BECAUSE THE APPRENTICES HAD TAKEN TRAINING IN DEBONING FOR A FEW WEEKS WITHOUT HOWEVER COMPLETING IT, FOUR TO SIX YEARS BEFORE THIS TRAINING.**

4.3 Follow-up of the training of apprentices in deboning in the "Femur" sequence

24 Each group of apprentices was followed, successively, for a period of six months, on a daily basis for the eight weeks of training; on a weekly basis for the next four weeks; and once every two weeks for the last three months. The total number of days of follow-up per apprentice varied from 45 to 56 days, depending on the apprentice. This variation in the number of days of follow-up is explained by the variable duration of the training from one group to another and by the days of absence of some apprentices. One of the seven apprentices (group 2) withdrew from training after 34 days. During all of the days of

training, there was audio and video recording of the training. The instructor and the apprentices wore microphones, except for one apprentice who asked that he not wear one. However, for this apprentice, we were able to record the knowledge elements verbally passed on to him by means of the recording made with the instructor. An individual interview with each apprentice before the start of training made it possible to know their actual experience and to document the symptoms felt before the training began. The daily follow-up of each apprentice was done in the following way: 1- meeting with the apprentice at the start of the work shift in order to collect information on the symptoms felt and to measure the grip forces. The discomfort level was evaluated on a scale of 1 to 5, with 5 being considered as "extreme discomfort" (Vézina et al., 1998); 2- evaluation of the knife's cutting quality by the instructor and the apprentice by means of an evaluation tool developed for this purpose (adapted from Vézina and Ouellet, 2002); 3- description of the method of organizing the training and the learning conditions (production rate, learning outside the production line or on the production line, work area, equipment, etc.); 4- meeting with the apprentice at the end of the work shift to collect the same types of data as at the start of the shift, but including a question about the level of general fatigue and a question about the difficulties encountered during the day; and 5- formal and informal verbalizations with the instructor to determine his perception of the apprentices' evolution and also to find out the difficulties that he himself had encountered during the day. As well, pieces of meat deboned by each apprentice were periodically evaluated using specific criteria (ex: knife strokes in the meat) to determine the learning level reached. We should mention that the organization of the first group's training was what the company had planned, based on past training experience. We therefore began with what existed so that we could then give recommendations to the company at the end of each group's training in order to improve the conditions for the next group. These recommendations were developed with the participation of the instructors and apprentices, but the procedure followed for this step will not be described in this article.

4.4 Analysis of the transmission of knowledge by worker-instructors

25 For the purposes of this article, we considered only the knowledge that was transmitted verbally to the apprentices, which does not rule out the instructor having made gestural demonstrations at the same time. It is understood that in manual trades, as is the case here, one must not ignore the fact that nonverbal communication contributes to the transmission of knowledge (ex: showing, demonstrating). However, the transmission of knowledge by nonverbal means could not be analyzed from video sequences because it is impossible to see precisely what the instructor is doing and to know what he wants to show the apprentice. The data would have been the result of our interpretation of the instructor's movements.

26 So in order to know what knowledge was transmitted verbally during training, we listened to audio recordings while noting the knowledge transmitted verbally by the instructors on a checklist developed from the list of knowledge elements identified in phase 1. Therefore, a check mark was placed on the checklist every time that the instructor transmitted information related to a knowledge element. We decided to make audio recordings of the first five days of training in the "femur" sequence for each of the apprentices, and for three other days chosen in relation to certain criteria, for a total of

eight days of data recording per apprentice. The first five consecutive days of training were chosen in order to make sure that at least the first phase of apprenticeship was covered, which consists of learning what has to be done, and part of the second phase of apprenticeship, during which the apprentices develop their own methods (Wulf, 2007; Chatigny et al., 2006; Schmidt and Lee, 2005; Vézina et al., 2003). The literature in motor learning mentions that during the first phase, the instructor must give more instructions, explanations and feedback (Schmidt and Lee, 2005; Schmidt, 1999) and that this first phase can last from a few hours to a few days. Since no study has demonstrated the duration of the first two phases of apprenticeship for manual and repetitive work tasks, we assumed that consideration of the first five days of training would ensure that we would cover the period during which the instructor would give the most instructions and explanations, and part of the period in which the apprentice would be likely to encounter difficulties in specific aspects of the methods, thus prompting the instructor to give more explanations on these aspects. The three other days were chosen in relation to certain criteria, the first of which are related to the discomfort or pain felt or the difficulties reported by the apprentice at the end of the day. The discomfort felt could be characterized by the onset of pain at the end of the day, the onset of pain the next morning, or by an increase in the level of pain at the end of the day or the next morning. When the days could not be chosen on the basis of these criteria, they were chosen in relation to some aspects of the context, such as the fact of returning to a stationary table after several days spent on a mobile production line. These criteria were chosen because we assumed that if the apprentice felt discomfort or if he verbalized the difficulties at a specific moment, the instructor could transmit even more knowledge related to these difficulties. The first of the three days chosen was situated, in relation to the apprentices, in a period from day 6 to day 8 of training on the “femur” sequence, the second day was in a period from day 9 to day 14 of training, while the third day was between days 15 and 23. It is important to mention that on these three days, the apprentices could also perform the other production sequences based on the level of learning reached. Only the knowledge elements transmitted during the performance of the “femur” sequence were noted.

4.5 Organization of deboning training and hours of listening

27 First we want to reiterate that the organization of group 1 training was that initially determined by the company, and that recommendations were given after each training session. This explains why differences were noted, from one group to the next, for some aspects related to the organization of training. First, we should mention that the apprentices in group 1 had to learn to perform all the deboning sequences right from the first day of training, while the apprentices in the two other groups learned the task in sequence. In fact, for these two groups, at least five complete days were devoted to learning only the “pelvis” sequence, and five other days for the “femur” sequence before these two sequences were combined to continue the apprenticeship. As a result, on the first five days of group 1 training, instructor H had to divide his attention and pass on knowledge related to several sequences, while for groups 2 and 3, the seven hours in the five days were devoted only to the “femur.”

28 Table 3 presents the breakdown of the training days given by each of the worker-instructors as well as the number of hours of audio listening done for these days. We

presented the breakdown of the first five days of training by using the concept of "period" in order to be able to show the number of times that each of the worker-instructors had to give these first five days of training. The presentation of the results relating to these first five days will refer to these periods. We can therefore state that instructor H gave the period of the first five days of training three times, while instructor D gave this period twice. In total, 56.5 and 45.6 hours of listening were done for instructors H and D respectively during this period. The first five days of training in deboning for group 1 were not given at the same time for apprentices 1 and 3 and for apprentice 2, because the apprentices/instructor ratio had been determined to be 2 to 1 at the start. However, regarding the three other days considered, instructor H was the instructor for group 1 only, while instructor D relieved him for groups 2 and 3. A total of 39.1 and 34 (22.4 + 11.6) hours of audio listening were done during this period for instructors H and D respectively.

Table 3. Breakdown of training days given by each of the worker-instructors (D and H) with the number of hours of audio listening done (no. of hours of listening)

	Group 1			**Group 2**		**Group 3**	
	# Apprentices						
	#1	#3	#2	#4	#5	#6	#7
Periods of first five days of training	Period#1 Instructor H (19.9)		Period #2 Instructor H (19.9)	Period #3 Instructor H (16.7)	Period #4 Instructor D (21.8)	Period #5 Instructor D (23.8)	
Three days chosen on the basis of criteria	Instructor H (39.1)			Instructor D (22.4)		Instructor D (11.6)	

29 Regarding the days chosen in relation to certain criteria, the average number of hours spent on the "femur" sequence for each of these days was 4.5 ± 2.1 hours for group 1, 4.9 ± 2.5 hours for group 2, and 2.2 ± 0.5 hours for group 3. The factors that can explain this variability are: 1-the learning level reached determined the gradual integration of the apprentices into the normal pace and work organization; 2-the difficulties encountered by some apprentices on a particular sequence, thus causing the time spent on the "femur" sequence to be increased or decreased; 3-the context existing at the precise moment on these days may have imposed a certain organization of training that did or did not favour the "femur" sequence, as for example, production constraints causing the "pelvis" and "femur" sequences to be combined, thus making a separate time compilation for these two sequences difficult. These differences in training organization could have had an impact on the number of knowledge elements transmitted per apprentice, and we will take this into account in our analyses. Only instructor D benefited from the last recommendations.

4.6 Processing of knowledge transmission data

30 Table 4 presents the type of processing carried out on the knowledge transmission data. As we can see, we first processed separately the data of the first five days of training and those of the three days chosen in relation to the criteria in order to then compare them. Subsequently, we considered, for all the days analyzed, the knowledge elements never transmitted and the knowledge elements not identified in phase 1 but transmitted to the apprentices. The result presentation ends with a summary profile of the strategies used by the worker-instructors to transmit their knowledge elements.

Table 4. Type of processing carried out on the knowledge transmission data

	First five days of training	Three days based on criteria
1	*/ for each worker-instructor* Total number of knowledge elements transmitted Total number of knowledge elements not transmitted Knowledge elements most often transmitted	
2		*/ for each worker-instructor* Knowledge elements transmitted Knowledge elements most often transmitted
3	Frequency of transmission of the knowledge elements most often transmitted	Frequency of transmission of the knowledge elements most often transmitted
	COMPARISON	
4	*/ for each worker-instructor* Knowledge elements never transmitted on all the days analyzed	
5	*/ for each worker-instructor* Knowledge elements not identified in phase 1 but transmitted to the apprentices on all the days analyzed	

5. Results: Knowledge of worker-instructors: Profile of its transmission

31 In this section, we will first discuss the knowledge elements that were described in phase 1 for each of the worker-instructors and that are potentially transmittable to apprentices. Second, we will present the knowledge elements in the previous list that are most often transmitted during the period of the first five days and on the three days chosen on the basis of criteria. Third, we will be interested in the knowledge elements that were never transmitted on all of the days of training considered in the study. To end, we will identify the knowledge elements that had not been verbalized by the worker-instructors in phase 1 but that were transmitted at one time or another on all the days of training analyzed.

5.1 Identification of knowledge elements to be transmitted: A preliminary step

32 The analysis of the work activity of meat deboners as well as the verbalizations with the workers during phase 1 of the study (Ouellet and Vézina, 2008) revealed several categories of knowledge that must be acquired to be able to do deboning work. In fact, we noted that there are knowledge elements related to different aspects of task performance, namely to the characteristics of the raw material, to the procedures, to work organization, to the production requirements, to the use of the tool, to the sensorimotor information mobilized, to the procedures applied, to the prevention principles aiming to reduce musculoskeletal stresses, to the safety rules, and to principles on "how to be." It is important to mention that since the apprentices followed in our study had experience in the company, some aspects were not explained in a formal way by the instructors, such as the rules for applying HACCP standards dealing with healthiness, and the safety rules implemented by the company. The instructors perhaps took it for granted that the apprentices had already received this information. However, we noted that these rules could be reiterated through comments made by the instructors, such as reminding an apprentice to have his knife in a sheath when moving around the room.

33 Considering that the general objective of our study was to promote MSD prevention, particular attention was paid to the knowledge elements that had been identified in the previous phase as being important aspects in the construction of efficient know-how elements that target both production and health protection. In the framework of this article, we consider only the knowledge mobilized in the application of these efficient know-how elements. This knowledge is associated with the characteristics of the raw material, with the procedures, with MSD prevention principles, with the use of the tool (types of grips), with the sensorimotor information mobilized, with "how to be" and with the operating methods. Tables 5a to 5g present these knowledge elements, which have the potential of being transmitted to the apprentices. Symbol "X" means that the worker-instructor verbalized this knowledge during the individual and/or group meetings conducted during phase 1. Note that the workers verbalized knowledge elements by mentioning only the "what to do," for example "opening and cleaning the "inside" during or after deboning...," while at other times, these knowledge elements were verbalized by also mentioning the "why," such as "opening and cleaning the "inside" during or after deboning...to avoid the downstream coworker." We therefore considered separately the knowledge elements on "what to do" and the knowledge elements on "why" in order to verify to what extent the intention targeted by an action was transmitted during training. All of these knowledge elements served in the construction of a data-recording checklist in the analysis of the transmission to the apprentices.

Table 5a. Transmittable knowledge elements related to the raw material's characteristics verbalized by instructors H and D

Transmittable knowledge elements ***Characteristics of the raw material***	**Instructors**	
	H	**D**

1.	Information about the characteristics of the pieces of meat and the bone	X	X

Table 5b. List of transmittable knowledge elements related to the procedures verbalized by instructors H and D

Transmittable knowledge elements ***Procedures***		Instructors	
		H	**D**
2.	Information about the order to be followed in certain steps...	X	X
3.	... to facilitate the work		X
4.	Information about the part of the blade to use	X	X

Table 5c. List of transmittable knowledge elements related to the prevention principles verbalized by instructors H and D

Transmittable knowledge elements ***Prevention principles***		Instructors	
		H	**D**
5.	Making fewer knife strokes...	X	X
6.	... to save time		X
7.	Not applying pressure...		X
8.	... to avoid pain (injuries)		X
9.	Avoiding certain postures - movements	X	X
10.	... to avoid pain (injuries)		X

Table 5d. List of transmittable knowledge elements related to tool use verbalized by instructors H and D

Transmittable knowledge elements ***Tool use***		Instructors	
		H	**D**
11.	Information about changing grips on the knife...	X	X
12.	... to be comfortable and avoid being poorly situated	X	X
13.	Instruction about the grip with the thumb on the handle / steps...	X	X
14.	... to reduce the effort and be comfortable	X	X

15.	... to have better control (pivoting of the knife)	X	X
16.	Instruction about the grip with the index finger on the back of the blade / steps...	X	X
17.	... to be more comfortable		X
18.	Instruction about the low grip...	X	X
19.	... to have a better grip/to exert less force		X
20.	... to feel the bone better		X
21.	Instruction about the full-hand grip on the handle	X	X

Table 5e. List of transmittable knowledge elements related to the sensorimotor information verbalized by instructors H and D

Transmittable knowledge elements		**Instructors**	
Sensorimotor information		**H**	**D**
22.	Visual cues for determining whether it is cutting at the right place	X	X
23.	Visual cues to know the depth of the blade	X	X
24.	Visual cues to anticipate the difficulties		X
25.	Cues to feel the bone or the movement		X
26.	Information about the mental representation made of the piece to know where his knife will go	X	

Table 5f. Transmittable knowledge elements related to “how to be” verbalized by instructors H and D

Transmittable knowledge element		**Instructors**	
On “how to be”		**H**	**D**
27.	Instruction about the importance of paying attention to what he is doing	X	X

Table 5g. List of transmittable knowledge elements related to the procedures verbalized by instructors H and D

Transmittable knowledge elements	**Instructors**
Operating methods	

		H	D
28.	Opening and cleaning the “inside” during or after deboning...	X	X
29.	... to avoid the downstream coworker	X	X
30.	... to not have to hold the piece – to save time		X
31.	Making 2 strokes (1 small) to expose the outside hock...	X	
32.	... to avoid being caught in a pile/to see better	X	
33.	... to make his work easier - the bone comes out easier afterwards	X	
34.	Making 1 stroke (1 small) to expose the outside hock...		X
35.	... so as not to make an unnecessary stroke		X
36.	Placing the piece of meat close to him (to avoid outstretched arms)	X	X
37.	Moving the piece of meat as little as possible...	X	
38.	... to be comfortable	X	
39.	Placing the piece of meat before starting deboning...	X	X
40.	... to be in a comfortable position	X	X
41.	Increasing the pace (speed and not the number of strokes) to make up for the time lost by a coworker upstream /To avoid an overload downstream		X
42.	Moving the piece of meat instead of moving himself...		X
43.	... to avoid the downstream coworker		X
44.	... to save time		X
45.	... to be more comfortable/to exert less force		X
46.	Placing hock end outside the table...	X	
47.	... to avoid being caught	X	
48.	Placing the ham diagonally or being at an angle/piece...	X	X
49.	... to avoid being caught and crooked	X	X
50.	Moving/turning the bone during deboning	X	X
51.	... to avoid having shoulders in the air	X	

Table 5g (cont.). List of transmittable knowledge elements related to the procedures verbalized by instructors H and D

Transmittable knowledge elements *Procedures (cont.)*		Instructors	
		H	D
52.	Beginning deboning upstream ...	X	X
53.	... to leave a margin of manoeuvre (time)	X	X
54.	... to avoid the downstream coworker	X	X
55.	Avoiding crossing hands during tracing of "inside" piece...		X
56.	... to avoid hitting left hand with the knife		X
57.	Making long knife strokes	X	X
58.	Looking at certain aspects while deboning	X	X
59.	Following the membrane between the parts of the piece...		X
60.	Going along the natural pathways in the piece of meat...	X	X
61.	... to reduce effort and knife strokes	X	X
62.	Following the bone – in contact with the bone	X	X

34 Table 6 presents a summary of the sum of the knowledge elements identified according to four classes, namely knowledge elements verbalized on "what to do," the knowledge elements verbalized on "why do it," the knowledge elements on sensorimotor information, and finally the knowledge elements on "how to be." We note that the knowledge elements verbalized by the worker-instructors mainly relate to "what to do" and "why do it". In total, 41 knowledge elements for instructor H and 52 knowledge elements for instructor D were considered for the transmission analysis. In the following sections, we will see which of these knowledge elements were transmitted and at what frequency.

Table 6. Total of the transmittable knowledge elements verbalized by instructors H and D according to four categories

Transmittable knowledge elements	Instructors	
	H	D
Total knowledge elements verbalized on *"what to do"*	*23*	*24*
Total knowledge elements verbalized on *"why do it"*	*14*	*23*
Total knowledge elements on sensorimotor information	*3*	*4*

Total knowledge elements on “how to be”	*1*	*1*
Total	**41**	**52**

5.2 Transmission of knowledge elements : Are some knowledge elements transmitted more than others ?

35 In Table 7 we present the number of knowledge elements presented in Tables 5 that were transmitted and not transmitted, as well as the total frequency of their transmission in the first five days of training. The analysis of the knowledge elements for the three days chosen in relation to the criteria will be presented in the following section. Thus, for instructor H (3 periods of 5 days of training), 41 knowledge elements were identified during phase 1, and of these knowledge elements, 25 were transmitted at least once, while 16 were never transmitted. In total, the knowledge elements transmitted were transmitted 340 times on the first five days of training. For instructor D (2 periods of 5 days of training), 52 knowledge elements were identified in the first phase, and 26 of them were transmitted at least once and 26 were never transmitted. These knowledge elements were transmitted a total of 387 times on these days of training. Thus, we note that 40 % of the knowledge elements identified for instructor H and 50 % of the knowledge elements of instructor D were never transmitted to the apprentices, which represents a significant percentage. We should mention that among the knowledge elements transmitted, we find only one knowledge element relating to “how to be” verbalized by the worker-instructors during phase 1, and that it was transmitted only twice by each worker-instructor.

Table 7. Number of knowledge elements in each category and total frequency of their transmission in relation to the worker-instructors involved

	Instructor H (3 periods of 5 days = 56.5 hours)				Instructor D (2 periods of 5 days = 40.7 hours)			
	Number of knowledge elements			No. times transmitted	Number of knowledge elements			No. times transmitted
	verbalized	transmitted (%)	not transmitted (%)		verbalized	transmitted (%)	not transmitted (%)	
Knowledge elements	41	25 (61%)	16 (39%)	340	52	26 (50%)	26 (50%)	387

36 Our interest then focused on identifying those knowledge elements presented in Tables 5 that were most often mentioned in the first five days of training (Table 8). As previously mentioned, the knowledge elements that were considered are those that are associated with the characteristics of the raw material, the procedures, the prevention principles, tool use (types of grips), sensorimotor information, the procedures, and “how to be.” These knowledge elements are involved in the construction of efficient know-how elements. In Table 8, we presented the knowledge elements that had been transmitted at least five times (number in bold print) by instructor H and instructor D. Thus, we note that the five knowledge elements that were most often transmitted verbally were the same knowledge elements for instructor H as for instructor D, despite the fact that the

organization of the training and the conditions offered to each group were different. The knowledge elements that were most often transmitted are :

1- "Information about the characteristics of the piece of meat and the bone" (knowledge element 1) ; 2- "information about the part of the blade to use" (knowledge element 4) ; 3- "visual cues for determining whether it is cutting at the right place" (knowledge element 22) ; 4- "opening and cleaning the "inside" during or after deboning" (knowledge element 28) ; 5- "following the bone – in contact with the bone" (knowledge element 62).

37 It should be noted that these five knowledge elements are all involved in the construction of efficient know-how elements (Ouellet and Vézina, 2008), but that four of them (#1, 2, 3, 5) are even more associated with the "production" aspect of the know-how elements. The *"opening and cleaning the "inside" during or after deboning"* knowledge element (#28) is associated with protection.

Table 8. Verbalized knowledge elements (Tables 5) that were most transmitted and their transmission frequency in the first five days of each of the training periods given by the two instructors

List of knowledge elements		Instructor H				Instructor D		
		period # (no. apprentices)				period # (no. apprentices)		
		#1 (2)	#2 (1)	#3* (1)	Total	#4 (1)	#5 (2)	Total
Characteristics of the raw material								
1	Information about the characteristics of the piece of meat and the bone	**17**	**15**	***36***	**68**	**18**	**10**	**28**
Procedures								
3	Information about the order to be followed in certain steps to make the work easier					4	**6**	***10***
4	Information about the part of the blade to use	**11**	**31**	***41***	**83**	**41**	**51**	***92***
Prevention principles								
5	Making fewer knife strokes	*4*	*1*	**5**	**10**	**14**	**10**	**24**
7	Not applying pressure on the knife					4	**24**	***28***
9	Avoiding some postures (arms - hands) and movements		*2*		**2**	**12**	4	**16**
Tool use								
11	Information about changing grips on the knife...		*3*	**7**	**10**	1	2	**3**

Sensorimotor information								
22	Visual cues for determining whether it is cutting at the right place	**5**	**8**	**18**	**31**	**10**	**18**	**28**
23	Visual cues to know the depth of the blade	1	**5**	**8**	***14***	3	1	**4**
25	Cues to feel the bone or the movement	4	**6**	**14**	***24***	3	**8**	**11**
Operating procedures								
28	Opening and cleaning the "inside" during deboning...	1	**5**	**12**	**18**	**21**	**8**	**29**
29	... to avoid the downstream coworker	**6**	4		**10**			
58	Looking at certain aspects while deboning		**7**		**7**			
60	Following the membrane between the parts of the piece of meat	1	3	**5**	**9**	**15**		**15**
62	Following the bone – in contact with the bone	**7**	**10**	**22**	**39**	**17**	**43**	***60***
Total		**57**	**100**	***168****	**318**	**163**	***185***	***348***

*** INSTRUCTOR H GAVE ONLY 4 DAYS OF TRAINING TO APPRENTICE 5 (TRAINING PERIOD #3) BEFORE BEING REPLACED BECAUSE HE WAS LEAVING ON HOLIDAYS.**

38 Since the most transmitted knowledge elements were the same for the two instructors despite the differences in the organization of training and in the learning conditions offered to each group, we can think that the emphasis placed on the transmission of these knowledge elements is even more influenced by the requirements of the task to be performed than by the conditions in which it is carried out, for example organization of the training (learning all the sequences together or by sequence), the type of workstation where the learning is done (stationary table or with a reduced pace on the fifth day), etc. Also, we can think that the importance given to the same knowledge elements by the worker-instructors is a reflection of a consensus within the experienced workers about the knowledge elements that must be transmitted.

39 Furthermore, the data in Table 8 also reveal that the two instructors present a different profile regarding the transmission of knowledge elements. In fact, for instructor H, we note a net increase in the knowledge elements transmitted during the last training period (168 knowledge elements) compared to the first (57 knowledge elements) despite fewer apprentices (1) and days of training (4) during this final period. If we examine the evolution in the transmission of each of the knowledge elements for this instructor, we note that the great majority increase over the training periods. The increase in the total number of knowledge elements transmitted is therefore not due to the increase in only a few knowledge elements, but instead, in all of the knowledge elements. As for instructor D, he shows a slight increase in the knowledge elements transmitted in his final training period (185 knowledge elements) as compared to the first (168 knowledge elements) despite the greater number of apprentices in the second period (2). Also, contrary to what

we noted for instructor H, there was no increase in the transmission of the majority of the knowledge elements during the second period. Some knowledge elements were transmitted more during the first period, while others were transmitted more during the second. We would have thought that the number of apprentices could have influenced upwards the number of knowledge elements transmitted, but we note for these two instructors that this is not the case. Certain factors, besides those related to the instructor's characteristics, could explain the inter- and intra-individual variability in the frequency of transmission of the knowledge elements presented in Table 8. Thus, we identify the characteristics of the apprentices that can lead to a more or less frequent repetition of certain knowledge elements (ex : apprentices with more difficulty with certain aspects of the task) as well as the dynamics of training development that could have led to these instructors reflecting on the knowledge elements to be transmitted.

40 Another fact to mention for the two instructors is that the majority of the knowledge elements transmitted are knowledge elements that help identify the location where the knife should pass and the appropriate depth of the blade in the piece of meat (knowledge elements : 1, 3, 4, 22, 23, 25, 60, 62). On this subject, the information collected during the daily meetings with the apprentices, in the verbalizations with the instructors, and from the evaluation of the pieces of meat shows that the apprentices had difficulty having the knife stroke at the right place in order to avoid leaving too much meat on the bone and inserting the blade not too far into the meat in order to avoid damaging it. Although these knowledge elements were first associated with the "production" aspect by the workers during phase 1, they then explained that having the knife stroke at the right place and using the right part of the blade also reduced efforts and the number of knife strokes. This explains why such knowledge elements were integrated into the list of knowledge elements that can be mobilized in an efficient know-how element. For the knowledge elements for which the verbalized objective is to protect health, and therefore related to the prevention principles or to a protection objective expressed in "why do it," we find few of them that were transmitted. In fact, for instructor H, only the knowledge elements "*opening and cleaning the "inside" during or after deboning to avoid the downstream coworker"* (#29) and *"making fewer knife strokes"* (#5) were transmitted more than five times, while for instructor D, we find only three of these types of knowledge elements that were transmitted on more than five occasions. These knowledge elements are :

> 1-"making fewer knife strokes" (knowledge element 5) ; 2-"not applying pressure on the knife" (knowledge element 7) ; and 3-"avoiding some postures (arms-hands) and movements" (knowledge element 9).

41 These results raise three questions for us : 1- Would this be because the instructors thought more about production than health protection ? ; 2- Would this be because they forgot to transmit the knowledge elements associated with the preventive aspect ? ; or 3- Would it be because they considered these knowledge elements as being basic knowledge elements that can not only help meet the production requirements but can also reduce efforts because they avoid making knife strokes "unnecessarily." The results in phase 1 lead us to believe that the most frequent transmission of production-related knowledge elements can be explained by the existence of a hierarchy in the knowledge elements mobilized by experienced meat deboners that assumes the necessity of developing knowledge elements associated with the "production" aspect in order to protect themselves successfully. The fact that the "production" aspect in task training usually occupies a large place in the targeted objectives, as is the case in our study, must not be ignored.

5.3 Apprentices' actual experience : What is its impact on the types of knowledge elements transmitted ?

42 Three days were chosen for each of the seven apprentices (21 days) in relation to criteria such as the discomfort felt, the difficulties encountered by the apprentices, and the context. Table 9 presents the knowledge elements that were transmitted on these days. It is interesting to note that 57 of the knowledge elements transmitted on these days (76 %) were transmitted on the days chosen in relation to the upper limb pain reported, which represents 57 % of the days chosen (total of 12 days out of 21). We also find a more varied number of knowledge elements on these days (N =16). This result could be an indicator of the difficulties experienced with aspects of the task that involve the mobilization of these knowledge elements, difficulties that could possibly explain the pain felt. We also note in Table 9 that few knowledge elements were transmitted on several occasions and that the one that was transmitted most often was, once again, the one involving the *"information about the part of the blade to use"* (knowledge element 4) particularly on the days chosen in relation to the upper limb pain reported (16 times). We also note in Table 9 that no cue for knowing the depth of the blade was transmitted by the instructors on these days, which led us to two questions : 1- Could the few cues transmitted for knowing the depth of the blade explain the fact why the apprentices, who had reached this stage of learning, seemed to have just as much difficulty identifying which part of the blade must be used ? ; and 2- Could this difficulty instead be linked to the fact that this aspect of the task requires great precision and good knowledge about the piece of meat, making it longer to master ?

Table 9. List of the knowledge elements transmitted verbally by the two instructors (combined) on the three days chosen in relation to criteria

List of knowledge elements		Pain		Difficulties(6 days)	Context(1 day)	Total (21 days)
		Back(2 days)	Upper limbs(12 days)			
1	Information about the characteristics of the piece of meat and the bone					**1**
4	Information about the part of the blade to use	2	16	4		**22**
5	Making fewer knife strokes		6			**6**
7	Not applying pressure on the knife	1				**1**
9	Avoiding some postures – movements...		3			**3**
10	... links to pain		1			**1**

11	Information about changing grips on the knife		1		1	**2**
18	Information about the low grip		1			**1**
22	Visual cues for determining whether it is cutting at the right place		9			**9**
27	Instruction about the importance of paying attention to what he is doing		1			**1**
28	Opening and cleaning the "inside" during or after deboning...		1			**1**
29	... to avoid the downstream coworker		3			**3**
36	Placing the piece of meat close to him (to avoid outstretched arms)		2			**2**
39	Placing the piece of meat before starting deboning...			1		**1**
40	... to be in a comfortable position		2			**2**
42	Moving the piece of meat instead of moving himself		3			**3**
50	Moving/turning the bone during deboning			1		**1**
52	Beginning deboning upstream	2	1			**3**
57	Making long knife strokes		1	2		**3**
58	Tricks about the glance direction			1		**1**
62	Following the bone – in contact with the bone		6	1	1	**8**
Total		**5**	**57**	**11**	**2**	**75**

43 Furthermore, we wanted to verify whether this knowledge element had been transmitted more frequently on the chosen days due to the pain reported (N ="21" days) compared to the period of the five first days of training (N ="24" days). We note in Table 10 that this was in fact the case, even though the difference is not very great, since the ratio between the frequency of transmission of this knowledge element and the total knowledge elements transmitted on these days (29.3 %) is greater than the ratio for the period of the

first five days of training (24.1 %). Note that for the three days chosen, we were able to have fewer hours of listening to the "femur" sequence, or 73.1 hours, than during the period of the first five days of training, with 102.1 hours. This leads us to assume that the difference could be even higher if we had had the same number of hours of listening. This result therefore implies that even after several days of training, this aspect remains poorly mastered by the apprentices and raises the question of a possible link between this lack of control and the reported pain.

Table 10 : Comparison between the transmission of knowledge elements most often transmitted on the three days chosen in relation to criteria (N ="21" days) and the transmission on the first five days of training on the "femur" sequence (N ="24" days)

		Period (first days) (24 days – 102.1 hours of listening)		**3 days chosen/apprentice (21 days – 73.1 hours of listening)**	
		No. times transmitted (Table 8)	No, times/727* (%)	No. times transmitted (Table 9)	No. times /75 (%)
4	Information about the part of the blade to use	175	24.1 %	22	**29.3 %**
5	Making fewer knife strokes	29	4.0 %	6	**8 %**
9 & 10	Avoiding some postures and movements	12	1.6 %	4**	**5.3 %**
22	Visual cues for determining whether it is cutting at the right place	59	8.1 %	9	**12.02 %**
2	Following the bone – in contact with the bone	99	13.6 %	8	10.6 %

*** THE TOTAL KNOWLEDGE ELEMENTS TRANSMITTED CORRESPONDS TO THE SUM OF THE DATA "340" FOR INSTRUCTOR H AND DATA "387" FOR INSTRUCTOR D IN TABLE 7.**
**** THE DATA ON KNOWLEDGE ELEMENTS 9 AND 10 IN TABLE 9 WERE ADDED SINCE THEY BOTH INVOLVE POSTURE-RELATED KNOWLEDGE ELEMENTS.**

44 In pursuing our reflection on the impact that the apprentices' sensations and feelings may have had on the frequency of transmission of certain knowledge elements, we did the same type of comparison with the knowledge elements "making fewer knife strokes" (#5), "avoiding some postures-movements" (#9), "visual cues for determining whether it is cutting at the right place" (#22) and "following the bone – in contact with the bone" (#62) since these are the knowledge elements that were transmitted most often on the chosen days. Thus, we note in Table 10 that even though the differences are small, there seems to be a tendency towards an increase in the transmission of the "making fewer knife strokes," "avoiding some postures-movements" and "visual cues for determining whether it is cutting at the right place" knowledge elements on the chosen days in

relation to certain criteria, despite a smaller number of listening hours. The data in Table 10 show that the transmission of these knowledge elements is particularly higher on the days in which upper limb pain was reported. Considering that the number of knife strokes made and the postures adopted constitute risk factors for upper limb pain, we can suspect that an association exists between the significant transmission of these knowledge elements, an indication of the difficulties encountered by the apprentices, and the pain that they feel. We make the same assumption for the "visual cues for determining whether it is cutting at the right place" knowledge element, since not having the knife blade cut at the right place in the piece of meat increases the risk of damage to the blade and, as a result, increases the effort by reducing the quality of the knife stroke, which is also a risk factor for upper limb MSDs.

5.4 Between "what to do" and "how to do it," what is transmitted ?

45 The data in Table 8 reveal that the knowledge element most often mentioned by the two instructors is the one dealing with "information about the part of the blade to use" (knowledge element 4) in relation to the parts of the bone. It is important to emphasize that this information dealt with the "what to do" and not with "how to do it" as shown by the two following examples : 1-*"There are places where you have to pay attention, your knife goes in too far ..." ;* 2-*"Put your knife here with the point..."* We can think that the high frequency of transmission of this knowledge element could be explained by the greater importance that the instructors give to this aspect. In fact, during the individual and group meetings with the workers during the first phase of the study, the experienced workers mentioned that it is vital to use the right part of the knife blade, in particular the "point" in order to do deboning correctly. Can we also think that this frequent transmission results from a need caused by the apprentices' difficulty integrating this aspect ? In such a case, we can question the impact of the frequency of transmission of a knowledge element solely focused on "what to do" without emphasis on "how to do it" since, according to the data in Table 8, the instructors transmitted very little the visual cues for knowing the depth of the blade (knowledge element 23). The frequency of transmission of this knowledge element is in fact among the lowest (Table 8). To explain our viewpoint, we present here an example that clearly shows that simple observation by the apprentice is insufficient to identify which part of the blade is used. On the second day of training of apprentice 2 (training period #2), instructor H mentioned *"Look, just with my point, I feel the top of my two joints (of the femur), there I go straight."* During this intervention by the instructor, apprentice 2 asked him to show him the length of the blade because he could not determine the depth only by observing him. The instructor showed him the part of the blade that was used. The apprentice mentioned to the instructor that when he tries to "see" the depth, he looks at the position of the instructor's hand in relation to the piece of meat. However, no one had realized that the apprentice's knife blade was longer than that of the instructor because his knife blade was new, while the instructor's had shortened with wear. Therefore, what the apprentice saw (position of the instructor's hand in relation to the meat) was inconsistent with the actual depth of the blade in the meat. After having had to intervene several times with this apprentice concerning the depth of the blade, the instructor decided to ask for a new knife to create the same condition as that experienced and seen by the apprentice.

5.5 Knowing how and being able to transmit it : When one does not guarantee the other

46 As we were previously able to note, several knowledge elements were transmitted at least once during the training (Table 7). However, the results show that there are also several that were never transmitted verbally. Tables 11 and 12 present the list of these knowledge elements that were never transmitted in all the days of training considered in our analysis (first five days + three chosen days) or for 22 days for instructor H and for 20 days for instructor D.

Table 11. List of the knowledge elements related to the "preventive" aspect of the know-how elements that were never transmitted by instructor H in all the days of training (n ="22" days)

Instructor H (N total knowledge elements verbalized = 41)
Knowledge elements associated with "what to do" (n knowledge elements already verbalized = 23)
1. Gripping with the thumb on the handle/steps (knowledge element 13)
2. Gripping with index finger on back of blade/steps (knowledge element 16)
3. Gripping with a low grip (knowledge element 18)
4. Using full-hand grip on the knife (knowledge element 21)
5. Making 2 strokes (1 small) to expose the outside hock (knowledge element 31)
Knowledge elements verbalized with "why do it" (n knowledge elements already verbalized = 14)
1. Gripping with the thumb on the handle ***to reduce the effort and be comfortable*** (knowledge element 14)
2. Gripping with the thumb on the handle ***to have better control*** (knowledge element 15)
3. Making 2 strokes (1 small) to expose the outside hock ***to make his work easier - the bone comes out better afterwards*** (knowledge element 33)
4. Making 2 strokes (1 small) to expose the outside hock ***to avoid being caught in a pile / to see better*** (knowledge element 32)
5. Moving the piece of meat as little as possible ***to be comfortable*** (knowledge element 38)
6. Placing end of hock off the table ***to avoid being caught*** (knowledge element 47)
7. Moving/turning the bone during deboning ***so as not to have shoulders in the air*** (knowledge element 51)
8. Beginning deboning upstream ***so as to leave a margin of manoeuvre (time)*** (knowledge element 53)
9. Beginning deboning upstream ***to avoid a downstream coworker*** (knowledge element 54)

47 For analysis purposes, we differentiated the knowledge elements that were expressed by the worker-instructors about "what to do" from those that were verbalized about "why do it," as for example, "beginning deboning upstream in order to have a margin of manoeuvre (more time)," as presented in Table 6. We note for instructor H (Table 11) that for a total of 23 knowledge elements expressed about "what to do," only five (21.7 %) were never transmitted, while out of a total of 14 knowledge elements verbalized about "why

do it," nine were never transmitted, which represents 64.3 % of all of these types of knowledge elements. As for instructor D (Table 12), we note that out of a total of 24 knowledge elements expressed about "what to do," six (25 %) were never transmitted, while out of the 23 knowledge elements verbalized about "why do it," 16 were never transmitted to the apprentices, which represents 69.6 % of these knowledge elements. We therefore note that the intentional component of the actions is transmitted much less than the instructions about "what to do," revealing either a lesser importance given to this aspect of the knowledge elements, or a misconception about the usefulness of transmitting the "why do it," or simply because the worker-instructors are still not sufficiently aware of these knowledge elements even though they had verbalized them during self-confrontation and group meetings.

Table 12. List of the knowledge elements related to the "preventive" aspect of the know-how elements that were never transmitted by instructor D in all the days of training (n ="20" days)

Instructor D (N total knowledge elements verbalized = 52)

Knowledge elements associated with "what to do" (n knowledge elements already verbalized = 24)

1. Placing the piece of meat close to him (knowledge element 36)

2. Making 1 stroke (1 small) to expose the outside hock (knowledge element 34)

3. Information about grip with the thumb on the handle/steps (knowledge element 13)

4. Information about grip with index finger on back of blade/steps (knowledge element 16)

5. Placing the piece diagonally or being at an angle/piece (knowledge element 48)

6. Doing the movement with the arm by cutting under the joint (knowledge element 59)

Knowledge elements verbalized with the "why do it" (n knowledge elements already verbalized = 23)

1. Information about the change of grip on the knife ***to be comfortable and avoid being poorly placed*** (knowledge element 12)

2. Instruction about the grip with the thumb on the handle ***to reduce the effort and be comfortable*** (knowledge element 14)

3. Instruction about the grip with the thumb on the handle ***to have better control*** (knowledge element 15)

4. Instruction about the grip with the index finger on the back of the blade ***to be more comfortable*** (knowledge element 17)

5. Information about the "low grip" ***to feel the bone better*** (knowledge element 20)

6. Opening and cleaning the "inside" during or after deboning ***to avoid the downstream coworker*** (knowledge element 29)

7. Opening and cleaning the "inside" during or after deboning ***so as not to need to hold the piece - to save time*** (knowledge element 30)

8. Making 1 stroke (1 small) to expose the outside hock ***so as not to make an unnecessary stroke*** (knowledge element 35)

9. Increasing the pace to make up for the lost time caused by a coworker upstream ***to avoid overloading downstream*** (knowledge element 41)

10. Moving the piece of meat instead of moving himself ***to avoid the downstream coworker*** (knowledge element 43)

11. Moving the piece of meat instead of moving himself ***to save time*** (knowledge element 44)

12. Moving the piece of meat instead of moving himself ***to be more comfortable and to exert less force*** (knowledge element 45)

13. Placing the piece at a diagonal or being at an angle/piece ***to avoid being caught and crooked*** (knowledge element 49)

14. Beginning deboning upstream ***to leave a margin of manoeuvre*** (knowledge element 53)

15. Beginning deboning upstream ***to avoid the downstream coworker*** (knowledge element 54)

16. Avoiding crossing hands during tracing...***to avoid hitting left hand with the knife*** (knowledge element 56)

5.6 Expressing your knowledge elements : When the training context suggests incorporated knowledge elements

48 In the previous sections, we addressed the question of knowledge elements identified by means of meetings with the workers and that were or were not transmitted to the

apprentices. But are there knowledge elements that were not verbalized by the worker-instructors during these meetings and that would have been transmitted during the training ? This is what we wanted to reveal by the data in Table 13 by presenting the list of the knowledge elements related to the "preventive" aspect of the know-how elements that had not been identified with the worker-instructors in phase 1 of the study but that were transmitted by them in all the days of training, therefore including the first five days and the three days chosen in relation to criteria.

Table 13. Knowledge elements related to the "preventive aspect, not identified in phase 1 of the study but transmitted by the worker-instructors (first five days + three chosen days)

Instructor H (22 days)	**Instructor D (20 days)**
1. Making fewer knife strokes ***to reduce the effort and the risks of injuries***	1. Having a good grip on the knife
2. Following an order in the steps ***to reduce the manipulation of the piece of meat***	2. Making fewer knife strokes ***to reduce the effort and the risks of injuries***
3. Avoiding touching the table with your knife	3. Having a grip on the piece of meat with non-dominant hand
4. Not applying pressure on the knife	4. Having a grip on the piece of meat with non-dominant hand ***to reduce injuries and have a better posture***
5. Reducing movements	5. Moving the bone during deboning ***to see better where to go***
6. Positioning yourself ***to be comfortable***	6. Reducing movements
	7. Reducing movements ***related to fatigue***
	8. Avoiding touching the table with your knife
	9. Avoiding passing over the bone
	10. Following an order in the steps **to avoid wasting time**
	11. Avoiding the index grip on the back of the blade for certain steps **so as to avoid pain**

49 We note that six new knowledge elements were transmitted by instructor H and eleven by instructor D. For instructor H as much as for instructor D, close to 50 % of these knowledge elements were verbalized about "what to do" and the other half verbalized about "why do it." For example, for instructor D, we find the "Having a good grip on the knife" knowledge element was expressed in terms of "what to do," and the "making fewer knife strokes to reduce the effort and the risks of injuries" knowledge element was verbalized with the "why do it." We can therefore think that the fact that the instructor is in the action or sees the apprentice in action brings to mind some knowledge elements that have become unconscious and therefore difficult to verbalize in a self-confrontation meeting. We also hypothesize that the self-confrontation and group meetings held during phase 1 prompted these worker-instructors to question their practice and to rediscover knowledge elements that they then verbalized in the context of training.

5.7 Transmitting knowledge elements : Overview of the strategies used

50 In the previous sections we discussed the question of transmission of knowledge elements by presenting those that were transmitted and those that were not transmitted. Several strategies used for transmitting knowledge elements may exist, as Cloutier et al. (2002) have already discussed. Even though the objective of our study was not to document in a detailed way the transmission strategies adopted by the instructors, we would like to draw attention to the transmission strategies that were identified by listening to audio recordings of the training and that could be the subject of future analyses. Thus, Table 14 presents an overview of the types of strategies used by the instructors to transmit their knowledge elements.

Table 14. Types of strategies used by the instructors to transmit their knowledge elements

Transmission strategies	**Relative frequency**
- Demonstrating - Demonstrating and explaining - Observing and giving feedback - Explaining the rules, procedures and techniques - Describing the results - Answering questions/asking questions	Most frequently
- Asking to perform and observing - Having mistakes found - Having your own mistakes found - Checking and confirming - Demonstrating and explaining another method as needed - Having other production workers observed (explaining the disadvantages of other methods based on another worker's work method)	Rarely

51 The strategies that seemed to us to be used most were those that involved demonstrations with or without explanations and those involving feedback after having observed the apprentice. By listening to the recordings, we noted that the instructors said very little when they did a demonstration. The instructor could mention : "Watch me, I am going to do one," without talking during the demonstration. This strategy could reflect the belief that people can learn just by watching the other person perform, or even the instructor's difficulty verbalizing his knowledge elements. Along these lines, instructor H told an apprentice to observe him in order to try to identify elements in his way of doing things. Instructor H mentioned to the apprentice that there may have been things that he forgot to tell him and that in seeing him perform the task, the apprentice could possibly identify them. In this specific case, the apprentice mentioned nothing new to the instructor after observing him.

6. Discussion

6.1 Stating the knowledge elements : Knowing how in order to protect yourself

52 In the previous article (Ouellet and Vézina, 2008), we revealed that to be successful in developing know-how elements that promote health protection, the worker must have previously integrated several knowledge elements and developed certain know-how elements more associated with production. For example, to develop the *"exposing the bone by giving the minimum necessary knife strokes"* know-how element, the worker must first develop two "production" know-how elements, namely to *"remove the bone by using the right part of the blade"* and to *"remove the bone by cutting at the right place"* as well as one know-how element associated with the preventive aspect, which is to *"remove the bone by conserving the cutting quality of his knife."* We also revealed that these know-how elements themselves involve the mobilization of many knowledge elements, several of which are production-related knowledge elements. For example, two tricks can be transmitted in order to pass at the proper spot, namely that of "following the bone – in contact with the bone" and that of "following the membrane separating the parts of the piece of meat." The workers later associated these two knowledge elements, which were first identified as being useful for meeting the production requirements, with a reduction in effort. Once we had verified whether there were knowledge elements that had to be transmitted to promote the application of these tricks, we noted that in fact other knowledge elements had to be developed in order to be able to develop these job tricks, as for example : 1- information about the parts of the blade to use ; 2- information about the order to follow in certain steps ; 3- not applying pressure on the knife handle to increase sensitivity, etc. Therefore, a hierarchy exists in the development of know-how elements and knowledge elements that must be considered in the analysis of the content to be transmitted in order to promote MSD prevention, whether they are associated with production or with prevention.

53 When the objective is to promote MSD prevention through training, we usually want to see the "preventive" knowledge elements developed by experienced workers transmitted to apprentices. As we anticipated, since the training was for occupying a workstation and for knowing the operations and was not training focused on prevention, production-related knowledge elements were transmitted much more often. However, we thought that the worker-instructors would have integrated this aspect more, particularly after having verbalized these knowledge elements. Still, as we previously mentioned, promoting the development of efficient know-how elements also means a good transmission of the "production" knowledge elements, because they are necessary for this development.

6.2 Demonstrating dexterity : Or knowing how, when and why to do it

54 Experienced workers are often described as workers who demonstrate great dexterity that allows them to deal with various more or less complex situations. What can characterize this dexterity ? On this subject, Latash and Turvey (1996, p. 207-210)

published a work devoted to dexterity, with the first part being the translation of a book written by Bernstein more than 50 years ago. The work of this Russian physiologist greatly influenced the theories about motor control. For Bernstein, dexterity is the capacity to judiciously carry out a motor task rapidly and precisely. Dexterity is not the actual motor output but is revealed instead in its interaction with the changes in external conditions (Latash and Turvey, 1996, p. 207-210). Dexterity is not related to the movement itself but instead to the objective of the action (Bril and Roux, 2002, p. 65). Furthermore, from a perspective of training future workers capable of solving the problems that they will face, and therefore showing dexterity, it seems desirable to us to promote a better transmission to the apprentices of the intentions targeted by the actions. To support our viewpoint, let's examine the phases in the motor learning process, as presented and used by several authors in the field of education and sports (Schmidt, 1999, Schmidt and Lee, 2005, Beckers, 2007) particularly the first two of the three stages, which are those of our study. First we find the initial stage which is the "verbal cognitive stage" in which the student must know the objective of the task, the steps to be carried out, the things to be done and not done, the time when he must do these things, how to do them, what he must look at as well as how he can evaluate performance. Then comes the second stage, which is the "motor stage" during which the student organizes patterns of movements to produce the action in relation to the situations. It is interesting to note that studies in workplaces have revealed, through verbalization with the workers, the existence of similar stages of learning (Vézina et al., 2003 ; Chatigny et al., 2006). As a result, if we again consider the elements to be known during the first stage, we note that several of these elements are "conditional," meaning that for the person to know what things have to be done or not done, he must know when he must do them and not do them, and why he must do them in certain circumstances and not in others. In this regard, Beckers (2007, p. 103) mentions that in the first stage of learning *"...the knowing how to do things (the "how") possibly represented in long-term memory, when it is not yet automatic, in the form of production rules anticipating conditions (if...), which will eventually be matched with the content of work memory, and actions (so...), which will prompt the execution of the procedure in the case of successful matching... It is therefore interesting for the instructor to complete the learning of how to do it through knowledge elements relating to the* ***"why"*** *and* ***"when"*** *to use the procedures."* (free translation) Here we present an extract from Cornu (1991, p. 83) expressed by a female office employee who decided to work as a plant worker, which clearly demonstrates the importance of transmitting the "why." This employee had mentioned : "*When we learn a new job, we are taught it by being shown how to do it. And I understand better when I am explained why it has to be done this way. Then I sometimes have minor difficulties and I break down the work after, to understand how to do it."* (free translation) From the standpoint of developing a training content, it is therefore important to promote the putting into words of the "why" of the movements made by the workers. There are "explicitation" interview techniques (Vermersch, 2006) to encourage the workers to explain their knowledge elements. These interview techniques reveal, through language formalization, what the expert possibly never had the opportunity to do. Along these lines, Teiger (1993) and Vézina et al. (1999) have already demonstrated the contribution of individual and group interviews in promoting the verbalization of job knowledge elements. This formalization will allow not only the worker-instructors to retrieve knowledge elements that have become unconscious, but also the construction of a training content that will subsequently serve as a memory aid during training. It would be just as important, for promoting the transmission of these knowledge elements, to

provide support for worker-instructors so that they develop competencies for transmitting their knowledge elements.

6.3 Sensorimotor knowledge elements that give meaning to movements

55 The results show that the cues associated with perceptive motor capacity, elements of the "how to do it," are transmitted less to the apprentices during training even though the frequency of transmission of several of these knowledge elements increased during the final training period given by each of the instructors. However, it is the cues that allow experienced workers to anticipate the difficulties and adjust their movements according to the situations (Chassaing, 2006 ; Gaudart, 1996). In fact, know-how implies that the person "knows how to observe," "has a sense of touch," "knows how to listen," "knows how to smell," and "knows how to taste," which implies the existence of perceptive motor cues (Ouellet and Vézina, 2008). For example, to know how to anticipate incidents from a machine's noise, the worker must know the different possible noises that can be heard and develop his cues. This does not mean that the apprentice will hear the same noises as his instructor or that he will hear them in the same way, but the transmission of these cues will give him the opportunity to be able to use them or have clues for developing others. How can the lower transmission of this type of knowledge element in our study be explained, given that the worker-instructors had already verbalized these knowledge elements during phase 1 of the study ? We can hypothesize that the low transmission of this type of knowledge element is due to the fact that these cues are part of the knowledge elements that have become incorporated and more difficult to verbalize (Teiger, 1996). Even though the workers had verbalized these knowledge elements during phase 1, they were verbalized in a context of self-confrontation and group meetings during which we used means to facilitate verbalization. This context is different from that of training, during which the worker must transmit his knowledge elements to apprentices, knowledge elements that he must remember alone without necessarily having support. Nevertheless, the noted increase in the frequency of transmission of these knowledge elements during the final training period, mainly for instructor H, shows that the development of a training improvement dynamic as well as the number of actual experiences of the worker-instructors during training can promote the verbalization of knowledge elements.

56 Furthermore, the fact of being in the action or the fact of having had to question themselves or be questioned by the apprentices about their actions brought back to mind certain knowledge elements. This could also explain why we noted that there are knowledge elements that had not been verbalized and identified during phase 1 and that the worker-instructors transmitted during the training. Along these lines, Boutte (2007, p. 116) emphasizes that *"The need to put into words and into action, in order to do and to demonstrate, to have done, to make understood, to teach causes the Experienced Professional, the Expert, to reformulate, rearticulate what he knows and that he is no longer aware of."* (free translation) The fact of putting into words and into movements, into arguments and explanations, therefore leads the Experienced Professional to clarify his know-how, to relearn in another way what he already knows, and possibly even to discover new knowledge elements (Boutte, 2007, p. 118).

6.4 Transmission of knowledge elements : Relationship to words and movements

57 We noted that the worker-instructors in the study spoke very little when they were doing demonstrations. This raises the question : To what extent can we learn just by observing others ? How many times have we heard from a company manager, *"We are going to put you next to this worker, and do what he does"* or from a worker, *"Watch me work and then try to do the same thing."* This type of instruction is often heard when the work is manual and repetitive because it is often seen as being not very complex and mainly consisting of a series of movements to imitate. But is it so easy to do the same thing ? If we refer to the definitions of "movement" presented in the literature (Bourgeois et al., 2006), the movement is thought about, chosen, adapted to the context, which suggests that just observing it is not enough for developing this movement. A movement always has intent, a motive (Boutte, 2007 ; Gandolfo, 2006 ; Bril and Roux, 2002) that is difficult to guess by observing it. In agreement with this, authors from different fields emphasize the insufficiency of demonstrations for developing a know-how element. For example, according to Boutte (2007) in the field of education *"the distinct action is indispensable, but it is supported by demonstrations as well as verbal explanations. The role of verbal mediation is in fact essential during the learning of a know-how element. The observer will have difficulty identifying the relevant parameters without verbal mediation."* (free translation) Desmurget (2006, p. 118), in the field of motor control, mentions that *"...the fact of seeing an expert subject performing a "perfect" movement in no way promotes the process of accommodation of schemes, a process which is however at the heart of all learning. In its classic form, demonstration informs the observer only about the characteristics outside of the movement to be produced. It communicates no information about the dynamic properties of the movement. Any incorrect estimation of these properties leads de facto to a significant deformation of the form of the movement..."*. (free translation) Still according to this author, learning should have its objective borne not by the formal attributes of the expert's action but instead by the acquisition of mechanisms that allow this action to be performed (Desmurget, 2006, p. 127). It is therefore important to go back up the chain of knowledge elements that allow expert workers to perform the movements.

58 When must the demonstration be accompanied by verbal instructions, and which aspects should the verbal instructions address ? Some publications in the field of motor learning relating to sports activities present elements of response to these questions (Davids et al., 2008 ; Wulf, 2007 ; Schmidt and Lee, 2005 ; Bertsch and Le Scanff, 2001 ; Schmidt, 1999), but how can these knowledge elements in the teaching and learning of activities be transposed into an actual work context ? Being able to answer this question would allow better guidance and accompaniment of instructors in the workplace, and as a result, make it easier for the apprentice to learn manual tasks. This question opens the way to interesting research perspectives.

6.5 Study of the transmission of knowledge : Contributions and limitations of the project

59 The ergonomic process developed in this study was an important contribution to the verbalization of the knowledge elements developed by the experienced workers, in

particular the two instructors, as well as to the analysis of the transmission of these knowledge elements in the context of formal training. The ergonomic process followed in the first phase with a group of experienced workers made it possible, through an in-depth understanding of the work activity, to produce a subtle description of the operating methods and the movements done by the workers. It also promoted the verbalization of the knowledge elements whose list served as a basis for the transmission analysis during the second phase of the study. However, it is important to mention that the identification of the knowledge elements by means of verbalizations with the workers can present a certain limitation because we can put into words only the knowledge elements that were described explicitly enough to be able to identify them. Some fuzziness may exist in the explanation given by the worker, which will prevent identification of the knowledge element without risking an interpretation. For phase 2, we favoured a process with daily follow-up throughout the training. This process made it possible to obtain very rich data and also to have latitude in the choice of the days for the analysis, particularly for the last three days chosen in relation to criteria linked to the apprentices' actual experience. However, in section 5.1 on the organization of training, we were able to see that this type of study, carried out in the workplace, has the limitation of being subject to contingencies generated by the dynamics of the environment (variable groups, variable hours, etc.). Considering that these variables cannot be controlled, we can only accept them and attempt to extract maximum information in order to enhance the analyses and the reflection on the dynamics of the work and its learning.

60 The knowledge brought into this project allowed the needs to be identified in order to ensure better transmission of the knowledge through the production of a training manual containing the knowledge elements verbalized by the workers and potentially transmittable by the instructors, as well as through an understanding of the genesis of the know-how elements that can guide how training is given (thinking of cues, thinking of whys, etc.). The proposed theoretical framework as well as the methodology developed, which led to the presentation of the knowledge element hierarchy, to the development of a checklist for studying the knowledge elements transmitted to apprentices, and to the development of a method for processing the knowledge elements transmitted, are also an important contribution of this project. Among its limitations, we can of course mention the cost in time required by such a study.

7. Conclusion

61 As we were able to note and as emphasized by Chevallier (1991, p. 1) "*Knowing how to do* does not necessarily mean *knowing how to transmit* or even *wanting to transmit*." (free translation) The results presented reveal that there are knowledge elements that are transmitted more than others, and that there are some that are never transmitted. We also noted that the cues, the "how to do it" and the intentions targeted by the workers through their actions, are transmitted very little to the apprentices. However, don't these cues allow experienced workers to anticipate the difficulties and adjust their movements in relation to the situations ? Doesn't expertise proceed from "how to do it" rather than from "what to do" ? Wouldn't a better transmission of the "why" of the actions (intentional component) promote the development of the apprentices' cognitive capacities in relation to their actions ?

62 Transmission is a complex phenomenon that requires being prepared for it ; as a result, it would be important to accompany worker-instructors in the development of competencies for transmitting their knowledge elements. How can a greater transmission of these numerous knowledge elements to the apprentices be promoted ? First, it is important to give worker-instructors the opportunity to verbalize and formalize their knowledge that can be integrated into training content and then offer conditions that facilitate this transmission. These conditions should ensure not only that an instructor has the time and equipment necessary for transmitting his knowledge but also that he wants to transmit it to the new workers. This motivation to transmit could be achieved through recognition of his contribution in the company and by valuing the role of instructor. Chevallier and Chiva (1991, p. 11) mention that, "Means must be found for encouraging holders of rare know-how to perpetuate it. Such a policy is achieved through a combination of complementary approaches, from seeking the social and cultural conditions for transmitting technical knowledge, to the valuing of jobs and products." (free translation)

Cloutier, E., Lefebvre, S., Ledoux, É., Chatigny, C., St-Jacques, Y. (2002). Enjeux de santé et de sécurité au travail dans la transmission des savoirs professionnels : le cas des usineurs et des cuisiniers. IRSST, R-316, Montréal, 217 p. www.irsst.qc.ca/fr/_publicationirsst_859.html

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ABSTRACTS

When training is being organized in enterprises where the work is considered as being repetitive and manual, the trainer is usually chosen from among experienced workers with recognized expertise. The study's aim was to analyze the types of knowledge transmitted by worker-trainers to apprentices in a food-processing industry in order to prevent musculoskeletal disorders. The knowledge orally transmitted by the trainers was analyzed from audio recordings of the daily follow-up of the training given. The ergonomic approach developed in this study has shown that knowledge linked to health protection, and to the "why" of movements and the benchmarks, aren't as easily transmitted as others. The complexity of the transmission phenomenon and the need to help worker-trainers in developing the competency for passing on this knowledge were demonstrated. Intervention scenarios are proposed.

Lors de l'organisation de formations dans les entreprises où le travail est considéré manuel et répétitif, le formateur est habituellement choisi parmi les travailleurs expérimentés dont le savoir-faire est reconnu. L'étude a eu pour objectif de faire l'analyse des types de savoirs transmis par des travailleurs-formateurs à des apprentis dans une entreprise du secteur agroalimentaire avec l'objectif de prévenir les troubles musculo-squelettiques. Une analyse des savoirs transmis verbalement par les formateurs a été effectuée à partir d'enregistrements audio provenant du suivi quotidien des formations données. La démarche ergonomique développée dans cette étude a permis de montrer que les savoirs liés à la protection de la santé, au « pourquoi » des gestes et aux repères sont plus difficilement transmis que d'autres. La complexité du phénomène de transmission et la nécessité d'accompagner les travailleurs-formateurs dans le développement de compétences pour transmettre ces savoirs ont été mises en évidence. Des perspectives d'intervention sont proposées.

Durante la organización de formaciones en empresas donde el trabajo es considerado manual y repetitivo, el formador es generalmente elegido entre los trabajadores experimentados que poseen un saber-hacer reconocido. Este estudio cuyo objetivo es de prevenir las lesiones músculo esqueléticas, analiza los tipos de saberes transmitidos a los aprendices por los trabajadores-formadores en una empresa del sector agroalimenticio. El análisis de los sabers transmitidos verbalmente por los formadores fue efectuada a partir de grabaciones audio provenientes del seguimiento cotidiano de las formaciones. El proceso ergonómico que se desarrolló en este estudio permitió mostrar que los saberes relacionados con la protección de la salud, el porqué de

los gestos y los puntos de referencia para el trabajo son más difícilmente transmitidos que los otros saberes. Se puso en evidencia que el fenómeno de transmisión es complejo y que los formadores necesitan ser acompañados en el desarrollo de competencias para transmitir los saberes . Proponemos perspectivas de intervención.

INDEX

Mots-clés: ergonomie, troubles musculo-squelettiques, formation, transmission, savoirs
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