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Subjective Ethnographic Protocol for Work Activity Analysis and Occupational Training Improvement

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

The renewal of the staff in companies, with no possibilities sometimes for the newcomers to meet experienced workers already retired, is considered by some analysts as a "skills drain". In such a context, improving the occupational training program is a crucial challenge for any company concerned by this social phenomenon.
The method presented here aims at providing an in-depth analysis of what makes the competencies of experience workers in order to provide more exhaustive input data for training. This might contribute to lessen the aforementioned problem. It uses subjective video recordings of work activities and applies co-analysis (researcher-worker) based on the Square of Perceived Action model developed for the purpose in the frame of Activity Theory.
The Square of Perceived Action-based method showed a better efficiency when compared with three other methods for four different activities. It also showed a good acceptance by the professionals who felt an improvement of their vocational practices after having being involved in such an analysis of their work activity.

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1. INTRODUCTION

Most long established French firms such as Electricité de France (EDF), and particularly Chinon Nuclear Power Plant (NPP), are subject to a high renewal of employees. For a plant as Chinon NPP which has 1200 employees (all professions included), in the next ten-fifteen years, 33% of population will be renewed and, currently, 50% of the staff will be renewed in the next 5 years. Young employees already represent 13% of the staff. This "exodus" is considered by some as a "skills drain".

In parallel, companionship and tutoring are getting less and less effective over time, not through any desire of the experienced workers, but due to the time left for such a mission: the workers explain that their workload is increasing while the teams become smaller. In this context, training as in practice or repetition becomes crucial in professional training.

We do need to improve identification of what must be taken from experienced workers in real operating situations with the objective to input innovative data into the training program. This concerns all companies touched by this phenomenon of skills drain and the method presented here might be of great interest for them. For this aim, we need to go deeply inside the work activity than what is done to date in the company. The challenge is to be both relevant (innovation) and efficient (fast results: developing a method which would imply several weeks of analysis per activity would not solve the problem as work activities concerned by this need are numerous).

The method used in the present approach was based on Le Bellu's work [1,2] which showed its performance addressing a nearby case to the present study. Her method was based on miniature camera mounted on helmet for subjective video recordings combined to simultaneous and situated verbalization. Recordings were analyzed through a protocol based on Subjective Evidence-Based Ethnography or SEBE [3] and Perceived Quality Theory [4-6]. Video analysis was chosen for the study because, as noticed by others, it contributes to a great extent to help researchers "to reveal how activities are produced with respect to the contingencies and circumstances of the participants within organizational settings, and examine how the technologies available in these domains are utilized" [7].

However Le Bellu's protocol had to be adapted: the differences lied mainly in the object studied (professional gestures for Le Bellu vs whole activity in context for the present study), in the number of subjects (individual activity vs individual or collaborative activity) and in the working context (fully controlled vs naturalistic). Experiments and applications were undertaken at Chinon NPP.

2. MATERIALS AND METHODS

2.1 Design

Phase 1 consisted first in clarifying the nature of what was relevant to be identified in the work activity to access what makes the skills and competencies of workers.

Phase 2 consisted in adapting Le Bellu's protocol [1] for data analysis in replay interview. In parallel, adaptation of the equipment was rather easy (see section "Apparatus").

Phase 3 was devoted to testing the designed protocol obtained in phase 2. Different activities of workers involved in the operation of nuclear reactor were chosen. The work situations were analyzed both on full scale simulators and in real operating situations.

Work activities chosen were:

- Individual setting of a neutral point on a pneumatic actuator of valve SEREG: the worker had to handle the actuator of a valve and to measure its displacement in order to identify the position of a neutral point and set it to optimizing the functioning of the associated valve.
- Individual setting of cams of a valve actuator: position of the cams had to be adjusted for optimizing the functioning.
- Collaborative hydraulic configuration of the circuit REA: a field worker and a reactor pilot had to work together in order to configure a part of a circuit called REA according to a given procedure.
- Collaborative implementation of the control-command curve G3 of the reactor

during test EP-RGL-4: two testing technicians had to carry out measurements in the control-command system with the help of a reactor pilot moving the control rods of the nuclear core according to the test need, and then had to implement new values inside the control-command system.

Activities were analyzed in this order. The first three ones were performed on a full scale simulator to assess risks for the workers and the industrial process induced by the equipment used for video recordings. The fourth one was undertaken in real operating situation. The two first activities were chosen because they were similar, short and easy to be performed on simulator. They were performed by the same worker and analyzed applying two methods: self-confrontation and our developed method. This repetition was necessary to assess the potential primacy effect due to the fact that the subject had to analyze twice his activity (one per method), the second analysis being potentially favored by the realization of the first one. Therefore, the subject performed the first activity, co-performed the self-confrontation analysis with an experienced trainer and later undertook the SEBE analysis with the researcher, and a month after the subject performed the second activity, co-performed the SEBE analysis and later the self-confrontation analysis. For the other activities, the methods compared to the SEBE analysis were undertaken by other teams of analysts and workers: they are described in section "Procedure".

Assessment of the methods' efficiency was done according to criteria presented in section "Procedure".

2.2 Apparatus

Due to recent technical progress, the size of the SEBE metrology equipment could be reduced compared to what Le Bellu [1] used in her experiments, therefore lowering the probability of interaction with the industrial environment in real operating situations. It was made up of three parts linked with cables: i) a micro audio digital recorder DVR-500-HD2 self powered by internal batteries, not much bigger than a mobile phone, ii) a 4 mm diameter - 40 mm length miniaturized subcam mounted on safety glasses, iii) a lavaliere microphone. This SEBE equipment was purchased at Active Media Concept. This equipment fulfilled the requirements of video quality, energy autonomy, data storage and size.

2.3 Procedure

2.3.1 Phase 1 – Nature of what makes the skills and competencies of workers

This consisted in clarifying terms such as skills and competencies and their interaction with knowledge and know-how. This preliminary analysis appeared necessary first due to controversies noticed in the literature and second due to possible misunderstandings between Francophone, Anglophone and east-European meanings of these terms. For this aim, the literature of these three scientific communities were considered and compared. The final result sought was not to obtain the absolute true definitions for these terms but to elaborate clear definitions adapted for this study.

2.3.2 Phase 2 – Adapting Le Bellu's protocol

This consisted in an analysis to adapt Le Bellu's protocol for interview [1] in order to preserve the character "naturalistic" of the activity (no repeated fully controlled situations, no simultaneous verbalization). The new protocol could be only elaborated upon a suitable model allowing us to analyze activity of a given worker in operating situation observed just once. Hence, a bibliographic research examined and selected the models available in the literature. Phase 2 resulted in the design of an adapted protocol for data acquisition and analysis.

2.3.3 Phase 3 – Testing the protocol obtained in phase 2

Phase 3 was testing the designed protocol and SEBE equipment selected in phase 2. For each activity, the analysis was carried out in two ways: one applying the SEBE protocol developed in phase 2, and one based on a method used in the company and widely used elsewhere. Then a comparison was done regarding two kinds of criteria: performance and efficiency. The performance criteria reflected the degree of depth reached to describe what make the skills and competencies of workers (the protocol outcomes); the efficiency criteria reflected the time and the resource needed to obtain the protocol outcomes. In addition, implementation criteria were considered, inherent to the SEBE equipment (e.g. negotiation with the management to undertake the investigation, installation of video devices and capture of the raw activity, obtaining subjects' informed consent) and to the SEBE interview (e.g. subjects' spontaneous participation).

Table 1 presents the four activities chosen for the test in the first column. For each one, the next columns precise where the activities were performed, the method which was used for activity analysis and compared with SEBE method and analysts' characteristics.

The methods compared to the SEBE method were: self-confrontation, SAT-based method and description-based method.

The self-confrontation was developed by Von Cranach [8], and later by Theureau [9] as a method of investigation of human activity through inter-dependent levels of action: the basis is the recovery of the ongoing subject's behavior through audio-video recordings, the recovery of the cognitive level guiding action by a self-confrontation of the subject to these recordings during interview. Self-confrontation is thus a deferred examination of the dynamics of structural coupling subject-situation supported jointly by means of reproduction of the behavior (e.g., video) and by the analyst as both observer and interlocutor [9].

The SAT method was elaborated as a Systematic Approach to Training developed in 1996 by the International Atomic Energy Agency [10], [11]. This was applied by the national training dept. of the company in order to identify what had to be taught in training sessions regarding each activity of each profession: professionals of the industrial trade and professionals of the training program met together and worked for several hours first to identify the activities related to a profession and second for each activity to identify i) pedagogical units (knowledge and know-how) to be acquired by trainees and ii) associated training units (available already in training programs or to be developed). This deployment then involved teams in each NPP for adjustment at a local level. At each level (national or local), 5 to 10 professionals gathered around a table for a brainstorming of several days spending about half an hour per activity. The NPP fleet including 20 sites, for a complete achievement of the process, this resulted at least in a 2.2 to 4.4 man.day cost ((5 to 10) x (20+1) x (½)/24); integration of local feedbacks were not quantified. In case of need of additional analysis for specific training adaptation regarding a difficult activity, this could lead to an additional day of analysis with 4 persons increasing the cost to 6.2 to 8.4 man.day.

Table 1. Specifications of the work situations used for comparative analysis

Activity (reference)	Location of the activity	Compared analysis method	Analysts' characteristics
Setting of a neutral point on a pneumatic actuator of valve (individual activity) Duration: 10 min. (TEST-IND-ROB-C1)	Full scale valve & tap simulator	self-confrontation	Simulator Trainer: Gender: male Age range: 41-50 yo. Duration in the position: 3 y.
setting of cams of a valve actuator (individual activity) Duration: 10 min. (TEST-IND-ROB-C2)	Idem	Idem	Idem
Hydraulic configuration of the circuit REA (collaborative activity) Duration: 60 min. (TEST-COLL-OP-AGT 01)	Full scale simulators (control room and industrial field)	SAT-based method	National Training dept.
Implementation of the control-command curve G3 of the reactor during test EP-RGL-4 (collaborative activity) Duration: 360 min. (ROS-COLL-OP-TT 01)	Real operating premises	SAT + Description-based method	Training Center of Chinon with the help of managers of the Testing dept.

Table 2. Subjects' characteristics involved in situations used for comparative analysis

Activity (reference)	Subject #1's characteristics	Subject #2's characteristics
Setting of a neutral point on a pneumatic actuator of valve (individual activity) Duration: 10 min. (TEST-IND-ROB-C1)	Simulator Trainer: Gender: male Age range: 41-50 yo. Duration in the position: 3 y.	None
Setting of cams of a valve actuator (individual activity) Duration: 10 min. (TEST-IND-ROB-C2)	Idem	None
Hydraulic configuration of the circuit REA (collaborative activity) Duration: 60 min. (TEST-COLL-OP-AGT 01)	Experienced pilot: Gender: male Age range: 41-50 yo. Duration in the position: 13 y.	Field worker: Gender: male Age range: 21-30 yo. Duration in the position: 3 y.
Implementation of the control-command curve G3 of the reactor during test EP-RGL-4 (collaborative activity) Duration: 360 min. (ROS-COLL-OP-TT 01)	Experienced Testing technician: Gender: male Age range: 40-51 yo. Duration in the: 15 y.	Testing technician: Gender: male Age range: 21-30 yo. Duration in the position: 3 y.

The description-based method consisted in sharing between trainers and technical experts of the trade what must be taught for a given activity according to their own work experience. From this exchange, trainers were in charge of writing pedagogical specifications for the design of the training session and they submitted it for critics, advice and complements to the technical experts.

2.4 Subjects

Subjects were selected according to their professional experience (Table 2 above). Preliminary, their managers were met to obtain an agreement and then subjects were presented the method and the goal: their participation was voluntary and they signed an informed consent form knowing that all data would be used anonymously.

3. RESULTS

3.1 Phase 1 – Nature of What Makes the Skills and Competencies of Workers

The aim of the protocol developed in the present study was to determine what makes up the skills and competencies of experienced workers in a refined and efficient manner. For this study to be quite clear, it was firstly necessary to define skills and competencies as the difference between them did not initially appear obvious when first looking at the scientific literature [12–45].

From this literature the main points of importance for the present study are summarized thereafter.

On the basis of a guideline [40] provided by the Northwestern University (USA) in 2004, Peregrin [41] reminded us that competencies could be seen as describing the skills, knowledge and behavior necessary to perform the job. In this case, skills would be abilities needed to execute job duties, such as software and computer proficiency accounting skills, or specific laboratory techniques (occupational competencies), and also interpersonal skills (generic competencies) (see also [42]). Knowledge would be linked with areas of specialty or expertise; for example, nursing, finance, employment law, or history. Behavior would be linked with characteristics an employee must display in the job; for instance, initiative, collegiality, resourcefulness or professionalism.

These concepts cannot be separated from action: Talyzina [43] highlighted how actions were necessary to achieve the learning process: "Actions thus are one of the components that determine the effectiveness of any learning process." We may extend her proposal to the previous considerations and suggest that actions contribute towards the subject elaborating know-how from knowledge.

Therefore, our research focused on knowledge in action to identify what makes workers'

competencies. The literature analysis highlighted another important characteristic: the spontaneity of the activity had to preserve as much as possible to ensure access to tacit knowledge in situation: for Polanyi [22], tacit knowledge is intuitive and spontaneous [44] and at the collective level, it results of the improvisation that summons the group of individuals in context [45].

3.2 Phase 2 – Adapting Le Bellu's Protocol

Le Bellu's work lied on Activity Theory and Perceived Quality Theory well adapted to structure the simultaneous verbalization and gestures analysis.

In the present study, we aimed at capturing and analyzing spontaneous activities (not only gestures) in industrial environment. It was better to structure the interview and the analysis upon a model of action, even upon a model involving competencies and action.

Exploring literature in order to find a model linking competencies and action in activity, one approach consisted in looking for models of action, and another one for models of competencies. Surprisingly, very few models were available in literature from either side.

Regarding models of actions, the model of Searle [46] was derived of the model of Davidson [47], the latter being called the "classical model" by Searle. Briefly, both are based on the subject's desire and belief to draw and trigger the action. Searle added the notions of rationality and free will before action and adjustment during action. None of them consider competencies related to action.

Gollwitzer [48] suggested a model of "action phases" with four different consecutive action phases of goal pursuit: the predecisional phase, the preactional phase, the actional phase, and the postactional phase [48-50]. The model suggested a comprehensive temporal perspective on the course of action and did not make link with competencies; it mainly dealt with goal intention and implementation intention.

The models of situated action [51-54] presented action as responses to the environment and the related goals as retrofitting constructions of the subject compared to the activity carried out. In this context, the subject does not develop the goals of the action. The action itself is therefore a reaction to the situation lived rather than an action in a situation. These models can hardly fit the theoretical frame chosen for the present work, the Activity Theory [55,56] within which we consider competencies coming through actions and being achieved within an activity situation, determined by intentions, goals and context.

The TOTE model suggested by Miller et al. [57] was innovative in that the authors were first modeling the contribution of mediating vectors between stimulus and response in action. They described action as successive steps and feedback within a progressive structure: Test – Operate – Test – Exit. Yet the action is thus restricted to a limitative cognitive process which does not relate to competencies and remains far from the notion of activity.

The same for the model of planned action [58,59] introducing the cognitive intentional dimension of action, as well as for Von Cranach's work [60]: the action was conceived as an intentional sequence linking action and representation in a complex relationship with long term considerations.

Regarding general models of competencies (as opposed to specific competencies models dealing for example with reading or leadership), the well-known Dreyfus's skills model [61] is limited to a suggestion of different steps characterizing the subject's levels of competencies with no explicit link to action.

The revised Bloom's taxonomy [62,63], approaching skills and competencies according to a classification of learning objectives into three domains (cognitive, affective, psychomotor) makes a link with action by introducing action verbs (analyzed in depth by many researchers; e.g. [64]) related to each categories; however, this approach, devoted to a mental activity, remains far from the notion of activity, and cannot easily address our concern.

The motor skills model of Argyle & Kendon [65] was elaborated to explain social interactions considering that social skills operate much like a serial skills motor. The model assumes subjects' motivation is sustained by goals which are achieved through a systematic and progressive loop adjusted by a perceived (perceptive capacities) and integrated (translation) feedback in order to respond to the outcomes of previous actions. This model is interesting in that it considers competencies coming through actions

(the feedback loop) and being achieved within an activity situation, determined by intentions and goals and context. The weakness of this model lies in a lack of descriptive relationships between competencies and action incorporated into the words “translation” and “feedback”.

The last model found in literature is the one proposed by Le Boterf [66] regarding competencies at work, explicitly associated with work activity. The model relates to action by the way Le Boterf depicted competencies at work involving action through the verb “to act”, “agir” in French. He defined competencies as a system of three poles: in French, “Savoir agir”, “Vouloir agir”, “Pouvoir agir”. Valdes Conca & de Juana-Espinosa [67] as other authors referring to Le Boterf’s French work, translated as the interaction of three poles: Knowing how to act, Wanting to act, Being able to act. This includes a mistake in the translation; the right meaning is: Knowing to act, Wanting to act, Being able to act. We shall argue this point soon.

The model defines thus competencies as an interacting system of three poles, drawing competencies as a triangle (Fig. 1). Knowing to act is that the professional will know to implement in situation, whether planned or unexpected, provided that it is within the bounds of the profession; this is the practical implementation of know-how, knowledge, all personal endogenous professional resources which combine themselves in knowing to act in situation. Wanting to act refers to the motivation and the personal commitment of the professional. Being able to act reflects the context of the situation of work, the external, exogenous resources of the professional (material means and logistical resources, work organization and social conditions that make it possible and legitimate responsibility and risk-taking of the professional) and endogenous resources (subjects’ capacities).

Le Boterf's model therefore suggested already the premise of the strong relationship between action and competencies through the verb "to act". We could go further by suggesting that Le Boterf's model is not a model of competencies, but a model of competencies in action. The link between competencies and action is mandatory in order to make competencies visible. According to the review analysis of Coulet [68], "competencies are manifest in the interaction of a subject (or a group) with a task in a given situation".

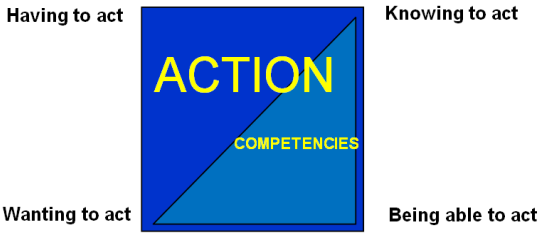

Fig. 1. The square of perceived action model (SPEAC model)

The question is here to determine what is missing to skip this model into the description of action. Referring to the Activity Theory, it is necessary to refer to the motives and goals in order to transform this model for action. This means that a fourth pole is expected in terms of Having to act. Hence the triangle of competencies changes into the square action of the subject, even more precisely the square of perceived action (Fig. 1). In the square of perceived action (SPEAC), Having to act is mainly shaped by the organization, driven by the order (client, manager) and by the definition of the task.

One could say that adding just one pole to Le Boterf's triangle of competencies makes it rather few to change it in a model for perceived action. Yet, one must consider that adding one pole doubles the interpolar relationships: There are three within a triangle and six within a square: the side relationships and the diagonal relationships.

The model was applied to describe actions regarding 50 different work activities, individual or collective, with success and was thus validated.

The SPEAC model was therefore used by applying a pole-based protocol of analysis through the interview. To do so, we considered each pole of the SPEAC model and integrated questions in the interview regarding both the positive and the negative aspect of the poles according to the new perspective of "negative goal" to be added in the Activity Theory as suggested by Lahlou (quoted in [2]). This relates to the necessity to take into account actions as well as non-action: “Non-actions are potential or possible actions not done but which might have been done, and are usually not observed”. [69: p79] Negative goals are related to the goals the subject does not want to reach; this approach is

presented as new in that, until then, activities analyses focused only on positive goals, the goals the subject wants to reach. Hence the questions are basically as follows:

- Pole Having to act for the questions:
  What do you have to do? / What do not you have to do?
- Pole Knowing to act for the questions:
  What do you know to do? / What do not you know to do?
- Pole Wanting to act for the questions:
  What did you want to do? / What did not you want to do?
- Pole Being able to act for the questions:
  What were you able to do? / What were not you able to do? (in terms of means, not related to the knowledge).

As pointed out above, the two poles Having to act and Knowing to act are mainly defined by the organization before doing the activity: the worker is usually aware of what s/he has to do before performing the activity due to the prescription, the procedure related to the task, the manager's order, and s/he knows to do it because, as a professional identified to perform this task, s/he "obviously" had an occupational training for this purpose. The prescription, the manager's order, as well as the professional training are for a great part defined before performing the activity through the task definition and the worker's official qualification.

Therefore, during the interview, it is interesting to question these two poles before watching the subjective video so that viewing the video does not influence the content of the answers: the subject is positioned as in the operating situation, void of a new exposure to the situation.

On the contrary the poles Wanting to act and Being able to act may be thought by the worker before performing the activity, but they may be continuously and significantly adjusted to the situation while performing the activity. These poles are less pre-defined by the organization than the two others. For the subjective video to remind the worker how performing the activity influenced the poles Wanting to act and Being able to act, they are questioned after the viewing in the frame of the interview.
Based on the SPEAC model, the structure of the interview is therefore designed as follow:

- Before watching the subjective video, the two poles Having to act and Knowing to act are questioned.
- A subjective re-situ interview is performed watching the subjective video.
- After watching the subjective video, the two poles Wanting to act and Being able to act are questioned.

The structure of the SEBE/SPEAC-based interview offers subsequently an interesting possibility: on one hand by analyzing the difference between answers to questions from one another, and on the other hand by analyzing the difference between answers to questions and the resulting content of the subjective re-situ interview, the analyst can identify potential tacit knowledge and differentiate it from explicit knowledge.

The developed protocol integrated the above considerations of phase 1: applied to work activities with a minimum preparation of the subjects in order not to decrease the spontaneity of the realization and favor access to tacit knowledge in situations; no anticipated or simultaneous verbalization was required.

The protocol was structured in four phases: preparation phase, capture phase, analysis phase, validation.

Preparation phase: This was to identify when the activity would take place and the corresponding work situation and to negotiate with the management to obtain the agreement to carry out the study. When the agreement was obtained, the management gave short explanation to the potential participants.

Capture phase: This was a direct contact with the participants: informing participants and obtaining informed consent about the capture phase, installing external and subjective video devices, framing, capturing the naturalistic activity, storing material and providing immediate feedback, and finally making appointments for the interview.

Analysis phase: This was a pre-view of the recordings without participants and selection by the researcher of particular sequences of the video for subjects to comment on them, interview sequences with participants, post-analysis of this interview by the researcher.

Validation: This was sharing the findings of the post-analysis with the participants, helping the researcher to validate the conclusions, helping participants to have feedback about their

knowledge and know-how as tacit, explicit, individual or collective.

3.3 Phase 3 – Testing the Protocol Obtained in Phase 2

The implementation criteria inherent to the SEBE equipment were all satisfactory for the four activities. Subjects' feelings including the disturbance were discussed and no special problem was noticed or reported. A risk assessment was undertaken before the real operating work situation [70].

Subjects' spontaneous participation was observed in all SEBE/SPEAC interviews: during exchanges, subjects took spontaneously the mouse to stop the video and explain what was going on. Interviews were thus satisfying therefore the implementation criterion inherent to SEBE interview. This seemed being favored especially by the relative position researcher/subject in front of the screen whilst viewing the videos (the screen was between them, not in front of one of them) and subjects were engaged to stop and restart the video according to what they wanted to comment or answer or show and were given the computer mouse in the hand at the beginning of the viewing. These findings were obtained by comparing the interviews recordings in the two first conditions; other methods of the two last configurations were not concerned by video.

The values of performance criteria elaborated according to the findings in phases 1 and 2 are summarized in Table 3. The first column reminds the activity which the comparison addresses, the second column reminds the method compared to the SEBE/SPEAC method, other boxes give ratios of the criteria. Regarding performance ratios, a value greater than 1 illustrates a higher performance of the SEBE/SPEAC method; when the denominator is null, the ratio is detailed. Regarding efficiency ratios, a value greater than 1 illustrates a lower performance of the SEBE/SPEAC method. In order to calculate these ratios, for the two first activities, analysts were asked to provide a table in which they listed knowledge identified as necessary and relevant to perform the task. Knowledge related to individual dimension had to be separated from knowledge related to collective dimension. In addition, knowledge regarding tacit dimension had to be identified by the analyst and discussed and validated with the participant during post-analysis. The numbers obtained were then used to calculate the ratios. For the two last activities, the analyst applying the SEBE/SPEAC method was asked to do the same. Regarding the other methods involved in the comparison, the protocol applied provided a list of knowledge related to the activity. An additional analysis was therefore undertaken to separate and count individual knowledge from collective knowledge and to specify whether some was tacit or not. The numbers obtained were then used to calculate the ratios.

Values show that the SEBE/SPEAC method had always a higher performance, identifying up to 9 times more knowledge than other methods and at least 1.45, distinguishing tacit and explicit knowledge in all cases whereas none of the other methods did it. Values also show a higher efficiency of the SEBE/SPEAC method compared to the others with a same duration of acquisition-analysis of data but a lower cost in terms of persons involved.

4. DISCUSSION

The following discussion is structured according to the criteria presented in sections 2.3.3 and 3.2. This makes the discussion more concise and relevant at it focused on the final product of the method.

Criteria from 2.3.3 helped us to assess implementation of the protocol and its efficiency. They were quantitative. These criteria were thought during the design of the experiment. Criteria from 3.2 were identified after the design of the experiment but however during the design of the protocol resulting of phase 2. They were qualitative. These criteria helped us to assess how deep the analysis could go by reaching innovative levels of analysis through identification of tacit knowledge and of non-actions or negative goals thereafter named "avoided trajectories".

Additional points are addressed: side effect of the protocol and risk assessment when using the protocol in high risk contexts. It appeared relevant to discuss these two points as useful for future users of the protocol.

4.1 Implementation

It may be surprising that implementation criteria were all satisfactory and that no particular problem was encountered. Especially, negotiation and appointment scheduling were rather easy. This might be put to the account of previous existing relationship between the researcher and the participants (by having

Table 3. Ratios of performance and efficiency criteria of the methods applied per activities

Activity (reference)	Analysis method	Individual knowledge	Collective knowledge	Tacit knowledge identification	Time spent for acquisition-analysis (days)	Product (man.days)
Setting of a neutral point on a pneumatic actuator of valve (individual activity)	Self-confrontation	1.75	3.00	Y/N	1.00	1.00
Setting of cams of a valve actuator (individual activity)	Idem	1.45	3.00	Y/N	1.00	1.00
Hydraulic configuration of the circuit REA (collaborative activity)	SAT-based method	9.00	13/0	Y/N	1.00	0.75
Implementation of the control-command curve G3 of the reactor during test EP-RGL-4 (collaborative activity)	SAT + Description-based method	3.00	5/0	Y/N	96.00	0.65

working together beforehand in other work analysis contexts) combined to the fact that both researcher and participants were employed by the same company. In case of hesitation to participate, what made the participant changing her/his mind was: i) a longer explanation of the motivation and the objectives of the research, including the presentation of the benefits for the participant(s), the colleagues and the company in terms of training efficiency and work performance improvement, ii) a detailed presentation of ethics protecting participants' interests, iii) the written engagement (informed consent form) co-signed by the participant and the researcher guarantying the anonymous use of the data including the prohibition to use the film by anybody else than the researcher in private research conditions except in case of written agreement of the participants.

4.2 Efficiency

The SEBE/SPEAC method was successfully compared to three other methods of work analysis in four configurations showing a better identification of knowledge. Table 3 gives a quantified account of the SEBE/SPEAC method advantage: higher number of knowledge identified, access to tacit knowledge, lower cost. When comparing the methods, the better efficiency of the SEBE/SPEAC method appeared to be due to a combination of the naturalistic context of the observed activity, the interview involving participants in the review of their actions and the inter-comparison of answers favored by the questioning structure.

4.3 Avoided Trajectories

The SPEAC-based structure of the questionnaire applied during the interview also showed its capacity to highlight avoided trajectories towards the goals. A fragment of transcription is presented hereafter adopting the widely used orthography developed by Gail Jefferson as suggested by Hindmarsh & Heath [71] for similar research on video analysis; further details are available in Atkinson and Heritage [72] and a

short overview of the orthography is given in appendix.

This example concerned the field worker handling valves during hydraulic configuration.

Fragment 1

Subject =S; Researcher=R
1.S: I didn't want to take shortcuts. This is because I was with you and I went through the official ways (.) otherwise I would have climbed over.
2.R: so what you tell me (.) it's because you were with me you took the way that were offi[cial (.)
3.S: [yes(.)
4.R: whi[le:::
5.S: [well sometimes it was easy to climb over and sometimes the valve was just behind I knew

Fragment 1 illustrates how the field worker avoided a physical trajectory which is also an activity trajectory in terms of goal: he could have gone easier and faster doing differently. Fragment 2 transcripts the explanation he gave regarding this choice.

Fragment 2

1.R: and: why the fact to be with me made you use the:: official ways?
2.S: well: because:: (blows = 03.0) well:: well it is not image to show (smile)
3.R: ah okay (02.0) the fact to climb over (.) it presents a: particular risk?
4.S: bah: it can produ=bah: falling: from height thus: it is always an additional risk (.)

He would have been pleased to climb over to shorten the way (save time and physical energy) illustrated by Fragment 1 - utterance 5 (referring to the positive aspect of Wanting to act), but he chose not to do it (referring to the negative aspect of Wanting to act): he did not want to show taking risk (Fragment 2, utterances 3-4) in front of an observer (Fragment 1, utterance 2). This was linked with the negative aspect of pole Having to act. Furthermore, the subject's difficulty to explain (Fragment 2, utterance 2) with blowing and elongated utterances completes the previous finding: what was avoided after self-made choice guided by personal considerations for less cognitive or physical energy spending was difficult to tell because of its conflict between Wanting to act and Having to act. This finding emphasizes here the dynamic dimension of the SPEAC model through the conflict between poles.

4.4 Tacit Knowledge

The inter-comparison of answers favored by the questioning structure of the SEBE/SPAEC protocol allowed us to notice that participants did not speak spontaneously of some knowledge. Instead sometimes explaining this omission by an oversight, they said "but it is obvious [to know that]" thus ignoring voluntarily this information. This situation then engaged the researcher to ask whether or not this knowledge was part of the basic knowledge expected for the profession (initial vocational training) and thus not relevant as a knowledge to be taught in a retraining cycle. If so, this was not counted as a tacit knowledge; otherwise, it was considered as probably tacit.

For other methods, no tacit knowledge was identified.

4.5 Side Effect

Furthermore, subjects' feedback obtained during the validation phase showed that all subjects felt an improvement of their professional practices after having being involved in the SEBE/SPEAC analysis of their activity. This finding was not surprising as this improvement induced by self-confrontation was already noticed elsewhere (e.g. [73]).

These findings led the head management of Chinon NPP to ask for application of the SEBE/SPEAC method for all the operating teams for training session. The opportunity was taken to ask subjects to fill a questionnaire regarding the assessment of the method. The results available to date confirmed the subjects' feeling of immediate significant improvement.

4.6 Risks Encountered Applying the SEBE/SPEAC Method

The SEBE equipment was unanimously accepted by subjects. Yet, other experiments [70] showed that precaution had to be taken regarding potential problems induced by the SEBE equipment. Hence a risk assessment is recommended for any type of SEBE methods before application to any real operating situation.

5. CONCLUSION

The results obtained let us conclude that the SEBE/SPEAC protocol integrating the re-situ

subjective goal oriented interview is an efficient method to identify knowledge that makes competencies of experienced workers. Compared to three other methods widely used, knowledge identification is more exhaustive (making it a powerful tool that will help industrials to improve their occupational training program) and low cost in terms of time spending and persons working (making it an interesting investment for companies). All the companies concerned by the phenomenon of skills drain might take benefits of the method presented here to improve their professional training.

The applications presented here concerned technical activities in industrial contexts exclusively. However we postulate that the method could be similarly applied to any other kind of work activities including managers' activities or office works.

The main limit of the method resides in the identification of tacit knowledge: according to our findings, any knowledge detected as potentially tacit during the post-analysis stage must be put into discussion with workers in order to validate it as tacit or not. Furthermore, for each identified tacit knowledge, it may be worth to evaluate the necessity to teach it rather than let it be elaborated through professional experience as showed elsewhere [74].

CONSENT

The author declares that written informed consent was obtained from subjects for publication of this paper.

ETHICAL APPROVAL

This study received ethical approval of the Ethics Committee of the Dept. of Social Psychology (LSE, London, UK) and has therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

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COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Le Bellu S, Lahlou S, Nosulenko V. Capter et transférer le savoir incorporé dans un geste professionnel [Capturing and transfering knowledge into a professional gesture]. Social Science Information. 2010;49:371-413. French.
2. Le Bellu, S. Capitalisation des savoir-faire et des gestes professionnels dans le milieu industriel [Capitalization of know-how and professional gestures in industrial environment]. PhD thesis, Un. of Bordeau. 2011;2011BOR21825. French.
3. Lahlou S. How we can capture the subject's perspective? An evidence-based approach for the social scientist. Social Science Information. 2011;50(3-4):607-655.
4. Nosulenko V. Mesurer les activités numérisées par leur qualité perçue [Measuring numerical activities by their perceived quality]. Information sur les Sciences Sociales. 2008;47(3):391-417. French.
5. Nosulenko V, Samoylenko E. Evaluation de la qualité perçue des produits et services: Approche interdisciplinaire [Assessment of the perceived quality of products and services: Interdisciplinary approach]. International Journal of Design and Innovation Research. 2001;2(2):35-60. French.
6. Nosulenko V, Samoykenko E. Psychological methods for the study of Augmented Environments. In: Lahlou S, editor. Designing User Friendly Augmented Work Environments, London: Springer Verlag. 2009;213-236.
7. Luff P, Jirotka M, Yamashita N, Kuzuoka H, Heath Ch, Eden G. Embedded interaction: The accomplishment of actions in everyday and video-mediated environments. ACM Transactions on Computer-Human Interaction. 2013;20(1): 6.1-6.22.
8. Von Cranach M. Goal-directed action. London: Academic Press; 1982.

9. Theureau J. L'entretien d'autoconfrontation comme composante d'un programme de recherche empirique & technologique [Selfconfrontation interview as part of a program of empirical & technological research]. Paper presented at the IIème Journées Internationales des Sciences du Sport [Second Int. Conf. for Sport Sc.], Paris. 2002;12-15. French.
10. IAEA. Guidelines for integrated risk assessment and management in large industrial areas. Report reference IAEA-TECDOC-994. International Atomic Energy Agency, Vienna (Austria); 1998.
Available:http://www-pub.iaea.org/MTCD/Publications/PDF/te_994_prn.pdf
Accessed August 2015.
11. The IAEA guidebook on nuclear power plant personnel training and its evaluation. Technical Reports Series No. 380; 1996.
12. Winterton J, Delamare - Le Deist Fr, Stringfellow E. Typology of knowledge, skills and competences: Clarification of the concept and prototype. Report of the European Centre for the development of vocational training, cedefop reference series: 64, Luxembourg: Office for official publications of the European Communities; 2006.
13. Boucher X, Bonjour E, Grabot B. Formalisation and use of competencies for industrial performance optimisation: A survey. Computers in Industry. 2007;58: 98-117.
14. Dodgson M. Organisational learning: A review of some literature. Organisational Studies. 1993;14:375-394.
15. Argyris C, Schön DA. Theory in practice: Increasing professional effectiveness, London: Josey-Bass; 1974.
16. Argyris C, Schön DA. Organisational learning, Reading MA: Addison-Wesley; 1978.
17. Bateson G. Steps to an ecology of mind, New York: Ballantine Books; 1973.
18. Nonaka I, Takeuchi H. The knowledge-creating company, Oxford: Oxford University Press; 1995.
19. Garvin D. Building a learning organization. Harvard Business Review. 1993;71(4): 78-91.
20. Senge PM. The fifth discipline: the art and practice of the learning organization. New York: Doubleday; 1990.
21. Polanyi M. Personal knowledge: Towards a post-critical philosophy. London: Routledge & Kegan Paul; 1958.
22. Polanyi M. The tacit dimension. New York : Anchor Books; 1967.
23. Wagner RK, Sternberg RJ. Tacit knowledge and intelligence in the everyday world, In: Sternberg RJ, Wagner RK, editors. Practical intelligence: Nature and origins of competence in the everyday world, Cambridge: Cambridge University Press. 1986;51-83.
24. Eraut M. Non-formal learning and tacit knowledge in professional work. British Journal of Educational Psychology. 2000;70:113-136.
25. Polanyi M, Sen A. The tacit dimension. Chicago, ILL: University of Chicago Press; 2009.
26. Garvin D. Building a learning organization. Harvard Business Review. 1993;71(4): 78-91.
27. Wenger E. Communities of Practice: Learning, Meaning and Identity, Cambridge, U.K. Cambridge University Press; 1998.
28. Proctor RW, Dutta A. Skill acquisition and human performance, London: Sage; 1995.
29. Boam R, Sparrow P. Designing and achieving competency, London: McGraw-Hill; 1992.
30. Hendry C, Arthur MB, Jones AM. Strategy through people: adaptation and learning in the small-medium enterprise. London: Routledge; 1995.
31. Woodruffe C. Assessment centres: identifying and developing competence, London: Institute of Personnel Management; 1990.
32. Ilyenkov EV. A Contribution on the question of the concept of “Activity” and Its significance for pedagogy. Journal of Russian and East European Psychology. 2002/2007;45(4):69-74.
33. Leontiev AN, Luria AR. The Problem of the Development of the Intellect and Learning in Human Psychology. Journal of Russian and East European Psychology. 1937/2005;43(4):34-47.
34. Leontiev AA. “Units” and levels of activity. Journal of Russian and East European Psychology. 2006;44(3):30-46. Translation from the Russian text “‘Edinitsy’ i urovni deiatel’nosti,” In Iazyk i rechevaia deiatel’nost’ v obshchei i pedagogicheskoi psikhologii (Moscow and Voronezh: IPO MODEK. 2001;66-82.

35. Sokolova E. Does activity theory have a future? Social Sciences. 2012;1:85-97.
36. Зинченко ВП, Мунипов ВМ. [Zinchenko VP, Munipov VM.] Эргономика и проблемы комплексного подхода к изу¬чению трудовой деятельности. [Ergonomics and problem of integrated approach to the study of employment]. Эргономика [Ergonomika]. 1976;10:29-59. Russian.
37. Montmollin (de) M. L'intelligence de la tâche: élements d'ergonomie cognitive [Intelligence of the task: elements of cognitive ergonomics]. Berne: Peter Lang; 1986. French.
38. Samurçay R. Concevoir des situations simulées pour la formation professionnelle [Design of simulated situations for vocational training]. In: Pastré P, editor. Apprendre par la simulation – De l'analyse du travail aux apprentissages professionnels [Learning through simulation - From analysis of work to professional learning]. Toulouse: Octarès. 2005:221-240. French.
39. Leplat J. Compétence et ergonomie [Competencies and Ergonomics]. In: Leplat J, Montmollin M, editors. Les compétences en ergonomie [Competencies in Ergonomics]. Paris: Octares. 2001;41-53. French.
40. Northwestern University. Guidelines for Writing a Competency Based Job Description. Report; 2004. Available:http://www.northwestern.edu/hr/compensation/Guidelines Competency based JD.pdf (Accessed August 2015)
41. Peregrin T. Competency-Based Hiring: The key to recruiting and retaining successful employees. Journal of the Academy of Nutrition and Dietetics. 2014;114(9): 1330-1339.
42. Heijke H, Meng C, Ris C. Fitting to the job: the role of generic and vocational competencies in adjustment and performance. Labour economics. 2003; 10(2):215-229.
43. Talyzina N. The contemporary condition of the activity theory of learning. Contemporary Educational Psychol. 1984;9:229-234.
44. Wasonga TA, Murphy JF. Learning from tacit knowledge: The impact of the internship. International Journal of Educational Management. 2006;20(2):153-163.
45. Erden Z, Krogh (von) G, Nonaka I. The quality of group tacit knowledge. The Journal of Strategic Information Systems. 2008;17(1):4-18.
46. Searle J. Rationality in action. MIT Press; 2001.
47. Davidson D. Essays on actions and events. Oxford: Clarendon Press; 1980.
48. Gollwitzer PM. Action phases and mindsets. In: Higgins ET, Sorrentino RM, editors. Handbook of motivation and cognition: Foundations of social behavior. New York: Guilford Press. 1990;51-92.
49. Heckhausen H. Motivation and action. Heidelberg: Springer-Verlag; 1991.
50. Faude-Koivisto TS, Wuerz O, Gollwitzer PM. Implementation Intentions: The mental representations and cognitive procedures of if-then planning, In: Markman KD, Klein WMP, Suhr JA, editors. Handbook of imagination and mental simulation. New York: Psychology Press. 2009;69-86.
51. Suchman L. Plans and situated actions. The problem of human-machine communication. Cambridge University Press; 1987.
52. Suchman L, Trigg R. Understanding practice: Video as a medium for reflection and design. In: JGreenbaum J, Kyng M, editors. Design at Work: Cooperative design of computer systems hillsdale. NJ: Lawrence Erlbaum. 1991;65-89.
53. Suchman L, Trigg R. Artificial intelligence as craftwork. In: Chaiklin S, Lave J. (Eds.), Understanding practice. New York: Cambridge University Press. 1993;144-178.
54. Fornel (de) M, Quéré L. La logique des situations - Nouveaux regards sur l'écologie des activités sociales [The logic of situations - New looks at the ecology of social activities]. Paris: Ecole des Hautes Etudes en Science Sociales; 1999. French.
55. Nardi B. Studying context: A comparison of activity theory, situated action models, and distributed cognition. In: Nardi B, editor. Context and consciousness: Activity theory and human-computer interaction. Cambridge, MA: MIT. 1995;35-52.
56. Leontiev AN. The problem of activity in psychology. Soviet Psychology. 1974;13(2): 4-33.
57. Miller GA, Galanter E, Pribram KH. Plans and structure and behavior. New York: Holt Rineart & Winston; 1960.
58. Fishbein M, Ajzen I. Belief, attitude, intention and behaviour: An introduction to

theory and research. Reading, MA: Addison–Wesley; 1975.
59. Ajzen I. From intention to actions: A theory of planned behavior. In Kuhl J. (ed.) Action control: From cognition to behavior. Beckmann, Berlin: Springer; 1985.
60. Von Cranach M. Social representations and individual actions: Misunderstandings, omissions and different premises. Journal of the Theory of Social Behaviour. 1995;24(3):285-293.
61. Dreyfus Stuart E, Dreyfus Hubert L. A Five-Stage Model of the Mental Activities Involved in Directed Skill Acquisition. Washington, DC: Storming Media; 1980.
62. Bloom BS, Engelhart MD, Furs, EJ, Hill WH, Krathwohl DR. Taxonomy of educational objectives: The classification of educational goals; Handbook I: Cognitive Domain. New York, Longmans, Green; 1956.
63. Krathwohl DR. A revision of bloom's taxonomy: An overview. Theory into Practice. 2002;41(4):212-218.
64. Ven JH, Chuang CP. The comparative study of information competencies-using bloom's taxonomy. Journal of American Academy of Business. 2005;7(1):136-143.
65. Argyle M, Kendon A. The experimental analysis of social performance. Advances in Experimental Social Psychology. 1967;3:55-98.
66. Le Boterf G. Évaluer les compétences - Quels jugements? Quels critères? Quelles instances? [Competencies assessment - Which judgments? Which criteria? Which instances?]. Education Permanente. 1998;135:143-152. French.
67. Valdes Conca J, de Juana-Espinosa S. The Competency-based Human resource management model. In: Human resources Management: Concepts, methodologies, tools and applications: Concepts, methodologies, tools and applications. Management association. Information Resources, IGI Global. 2012;232-252.
68. Coulet JC. Capacités dynamiques et innovation: Les apports d'un modèle psychologique des compétences individuelles et collectives [Dynamic capacities and innovation: contributions of a psychological model of individual and collective skills]. Conf. Ass. Intern. de Management Strategique, Nice (France); 2013. French.
Available:http://httpcdiaims2013.sciencesconf.orgconferencecdiaims2013pagescdiaims2013_coulet.pdf/
(Accessed August 2015)
69. Fauquet-Alekhine Ph, Labrucherie M. Simulation training debriefing as a work activity analysis tool: The case of nuclear reactors pilots and civil aircraft pilots. Socio-Organizational Factors for Safe Nuclear Operation. 2012;1:79-83.
70. Fauquet-Alekhine Ph. Risk assessment for subjective evidence-based ethnography applied in high risk environment. Advances in Research; 2015. (in press)
71. Hindmarsh J, Heath Ch. Sharing the Tools of the Trade: The interactional constitution of workplace objects. Journal of Contemporary Ethnography. 2000;29(5): 523-562.
72. Atkinson JM, Heritage J. Structures of social action: Studies in conversation analysis. Cambridge: Cambridge University Press; 1984.
73. Clot Y, Fernandez G, Carles L. Crossed self-confrontation in the clinic of activity. Proceedings of the XIe Eur. Conf. on Cognitive Ergonomics. Catalina, Italia. 2002;13-18.
74. Fauquet-Alekhine Ph, Daviet Fr. Detection and characterization of tacit occupational Knowledge through Speech and Behavior Analysis. International Journal of Innovation, Management and Technology. 2015;6(1):21-25.
75. Heath Ch, Luff P, Svensson MS. Video and qualitative research: Analyzing medical practice and interaction, Medical Education. 2007;41:109-116.
76. Hindmarsh J, Heath Ch, Fraser M. (Im)materiality, virtual reality and interaction: Grounding the 'virtual' in studies of technology in action. The Sociological Review. 2006;54(4):795-817.

APPENDIX

All transcribed dialogues are drawn according to the widely used orthography developed by Gail Jefferson as suggested by Hindmarsh & Heath [71] for similar research on video analysis; further details are available in [72].

The identity of the speaker is indicated in the margin, sometimes alongside a line number.

The following example shows lines 1 and 2 then 3 and 4 of a transcript, in which the interlocutor A questions interlocutor B. The description of symbols is given after (adapted from appendix of Heath et al. [75]).

1. A: You can give me an:: an(.) example (0.2) for this?
2. B: No.

(0.2) A pause timed in tenths of a second.
(.) A pause which is noticeable but too short to measure.
an:: Elongated utterances; the longer the elongation, the more colons are added to the utterance or section of the utterance.
example Louder stretches of talk are underlined.
. A stopping fall in tone, not necessarily the end of a sentence.
? Rising inflection, not necessarily a question.

Here is another example to illustrate how to draw the overlapping in the dialogue. Overlapping utterances are marked by parallel square brackets:

3. A: It (was) very [very warm
4. B: [yeah=However:: we did it

(was) Words or utterances that are difficult to hear.
[Overlapping.

= No discernible interval between adjacent utterances.

Here are other symbols:
[…] Speech not transcribed.
[laughs=02.4] Laughs for 02 seconds and 4 tens of second.
[cough=02.4] Cough for 02 seconds and 4 tens of second.

Examples of application may also be consulted in Hindmarsh & Heath [71] and Hindmarsh, Heath & Frazer [76].

Peer-review history:
The peer review history for this paper can be accessed here:
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