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The Square of PErceived ACtion Model (SPEAC Model) Applied in Digital Ethnography for Work Activity Analysis: Performance and Workers' Perception

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The SPEAC protocol using first-person perspective ethnography and subsequent replay interviews was applied to analyze work activities at a French nuclear power plant during real operating situations of Operations shift teams (15 situations and 30 participants, about 1950 min. video recordings and 2400 min. audio recordings). Results were compared with those obtained with the standard method applied in the French nuclear fleet (Systemic Approach to Training: SAT). Both SPEAC and SAT methods provided knowledge and know-how necessary to perform work activities. Following each analysis, participants were presented with a questionnaire for assessment of the method. Items addressed efficiency, constraints, extended application to colleagues or other activities. SPEAC method showed a significantly higher level of identification of knowledge and know-how per activity (from 1.9 to 9 times more) than SAT and at a lower cost. The SPEAC method

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evaluation by participants was positive, with a good consistency of answers. Trainees considered that i) analyzing the subjective film was perceived as a real added value compared to a classic method (without subjective film, ii) the new method induced faster progress iii) the overall perception was positive) iv) the method was worth being deployed to other activities. Bias, limits and perspectives are discussed.

Keywords: Activity analysis; activity theory; video; occupational training; competencies; knowledge; high risk industry; digital ethnography.

1. INTRODUCTION

Industries are subject to a high renewal of employees and must now come to terms with the problem of maintaining competencies [1-5]. For example, in the next ten-fifteen years, the 1300 employees at Chinon Nuclear Power Plant (NPP) of Electricité de France (EDF) will be renewed by 33% of population and, currently, 50% of the staff will be renewed in the next 5 years. Young employees already represent more than 20% of the staff. This churn can create a skills drain unless competencies are "transferred". Novices used to learn, beyond formal training, by "peripheral participation" [6] during companionship on the job with their elders; but that dovetailing is becoming less frequent and shorter. This occurs in a work environment with drastic requirements of operational and safety standards [7-9]. The combination results in increasing difficulties for workers to fully apply procedures or use tools efficiently.

In this context, the quality of formal training becomes paramount [10]. We need to make sure the necessary skills are addressed by training programs. To this aim, we need to analyze the work activity more thoroughly than has been done until now, and identify what competencies are used by experienced workers in real operating situations. This analysis must be 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.

We set up protocol adapted from digital ethnography, based on Le Bellu and co-researchers' work [11-16] and recommended by others; see for example [17]. Digital ethnography is a science aiming at understanding subjects' life in their personal and cultural perspective through data obtained in the field and video recorded and from discussions with subjects themselves [18]. The protocol, described in detail in [19] is based on the capture of the subjects' work activity through a first-person perspective video recording (subcam; see [20]) followed by a replay interview based on the Square of PErceived ACtion model (SPEAC model). The method is thus not anodyne for the subjects who have to wear additional video equipment during their work and then have to re-question their competencies with the analyst during an interview. The protocol was tested in previous studies [19,21] mainly on full scale simulators during occupational training. It remained to be tested in real operating situations, which is the purpose of this paper.

At the same time, the question of the acceptance of the SPEAC model-based protocol by workers came up: previous studies [19,21] were undertaken on simulators and now it was to be applied in real operating situations; the stakes and constraints are not the same in the two contexts. In real operating situations, the fear was that participants might refuse to wear additional equipment or to spend time for interviews. While acceptance during simulations was good, in real operating situations participants might not appreciate being disturbed by the video equipment; furthermore, analyzing competencies in interview might be perceived as an uncomfortable introspection and/or a disguised, unacknowledged job performance assessment.

The SPEAC protocol was thus applied to analyze work activities at a French nuclear power plant during real operating situations. The situation cases selected to undertake the assessment were collaborative activities in Operations shift teams.

2. MATERIALS AND METHODS

2.1 Design

The SPEAC-based method was applied to analyze hydraulic configuration, Lock & Tag

activities and periodical tests (described in section 2.5) at a French nuclear power plant during real operating situations, and performed by Operations shift teams as part of their routine work. The SPEAC-based method implied a short preparation with the participants, a capture phase of the activity to obtain a subjective video recording of each worker's activity, then a "replay interview" (RIW) where participants comment their own first-person perspective recording to the analyst, followed by an analysis by the researcher to identify knowledge and know-how necessary to perform the activity and a validation phase (description in sections 2.2 and 2.3).

The SPEAC-based method provided an identification and description of knowledge and know-how necessary to perform each activity and used later as input data for occupational training. The results were compared with those provided by the Systematic Approach to Training (SAT), a standard method applied in the French nuclear fleet in order to identify what had to be taught in training sessions regarding each activity of each profession. The SAT method is described in section 2.4.

Following SPEAC-based analysis of work activities, subjects were individually presented with a 9-item questionnaire (described in section 2.6) for self-assessment of the method.

2.2 Apparatus for Subjective Video Recording

The digital ethnography equipment, also said Subjective Evidence-Based Ethnography equipment (SEBE equipment) [13], 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 camera (subcam: [20]) mounted on safety glasses, iii) a lavaliere microphone. This SEBE equipment was assembled from components produced at Active Media Concept (website: www.amc-tec.com). This equipment fulfilled the requirements of video quality, energy autonomy, data storage, size and industrial environment disturbance. The main advantage of this equipment was to be adaptable to any kind of glasses (safety or vision).

2.3 Procedure

The procedure applied for work activity analysis was developed, tested and validated in a previous work [19].

The schema of the protocol was the following:

- At the beginning of the shift, the analyst exchanged with the Operations team during the shift briefing to identify which activities might be analyzed and who would be volunteer to be involved in the activity analysis; usually one or two pairs of workers were identified (a pair is a field worker and a reactor pilot involved in the joint activity).
- Workers were separately informed of the aim of the study, signed an informed consent and undertook a risk assessment regarding the subcam used in real operating situation [21,22]. Then they were equipped with the subcam. This lasted about 5 min. for each subject (preparation phase).
- Workers performed their activity (lasting from 10 min. to several hours), recording at the same time a subjective video of their activity (capture phase).
- At the end of the activity, workers gave the subcam equipment back to the analyst and returned to their work; during this time, the analyst performed a pre-analysis of the subjective video for the two workers in order to select video sequences of interest and prepare possible questions (about one hour per subfilm).
- During the shift or during one of the following shifts, subjects were met individually and then collectively to undertake the RIW (analysis phase). In order to respect the participants' workload, it was negotiated with the management that interviews would not last more than 1 h each. The RIW was based on self-confrontation and explicitation techniques. A post-analysis of the interviews (audio recorded) was carried out by the analyst to produce the output data regarding competencies.
- These resulting output data were finally discussed with representatives of the professions for validation (validation phase).

RIW [13] takes from techniques of self-confrontation and explicitation interview described hereinafter. This method is similar to the cued recall debrief developed by Omodei & McLennan [23] and applied by others (see for example [24,25]). The SPEAC model helps the analyst to structure the interview topic guide by providing four poles for questions (see below).

The self-confrontation was developed by Von Cranach [26], and later by Theureau [27] as a method of investigation of human activity through inter-dependent levels of action: the principle 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 investigation of the dynamics of structural coupling between subject and situation, supported jointly by means of reproduction of the behavior (here video) and by the analyst as both observer and interlocutor [27].

Explicitation interview [28] is the implementation of a descriptive speech actions experienced by a subject. This implementation may be based on physical, organizational or psychological traces of the activity. The technique offers a framework and guidelines to lead the researcher in how to conduct the interview, and through this questioning, to make the subject aware of the action and of the way it was performed. Following the generic SEBE recommendations for analyzing first-person perspective video, we use activity theory to structure the questions and capture the motives and goals and subgoals of activity [13].

The Square of PErceived ACtion model (SPEAC model) structuring the interview describes competencies in action. The model, extended from Le Boterf's model [29], defines competencies in action as an interacting system of four poles [19], drawing competencies as a square (Fig. 1). *Having to act* refers to the motives and goals in order to transform this model for action. It is mainly shaped by the organization, driven by the order (client, manager) and by the definition of the task. *Knowing to act* is what 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 embodied professional resources which combine into 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). While some of these poles may be redundant, asking the questions with all of them ensures all aspects are covered. The SPEAC model is thus intended to describe the necessary conditions for the subject to successfully put competencies in action: if one pole is deficient (for example: a lack of knowledge that relates to the pole *Knowing to act*) or if there is any conflict between poles (for example: when the subject must do something but does not like to do it; this leads to a conflict between *Having to act* and *Wanting to act*), then competencies will not be successfully put in action.

Activities being goal-oriented [30], the protocol permitted access to the trajectories followed or avoided by the workers to reach the goals during the realization of the work activity. It thus helped analysts to explain the way trajectories to a goal had changed by applying a pole-based protocol of analysis through the RIW. To do so, we have suggested to consider each pole of the SPEAC model and to integrate questions in the replay interview regarding both the positive and the non-positive aspect of the poles according to the perspective of "negative goal" as suggested by Lahlou (quoted in [12:372]). 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" [31:79]. Negative goals are related to the goals the subject does not want to reach, or states and events the subject wants to avoid.

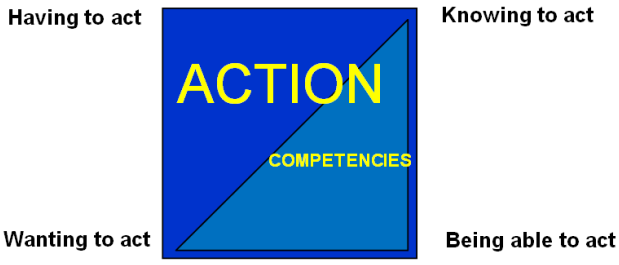

Fig. 1. The square of perceived action model (SPEAC model)

The innovation of the protocol relied in the structured questioning during the interview addressing the four poles of the SPEAC model:

- What I have (not) to do (pole *Having to act*)
- What I (do not) know to do (pole *Knowing to act*)
- What I (do not) want to do (pole *Wanting to act*)
- What I am (not) able to do (pole *Being able to act*)

In practice, per activity, applying the SPEAC protocol required 2 persons (including the work analyst) during 4 hours to achieve the whole analysis (including activity capture) and 3 persons (including the work analyst) during 1 hour for all interviews. Assuming a day of work is 7 h on average, the resulting cost is 1.5 man-days.

2.4 The SAT Method

The SAT method was elaborated as a Systematic Approach to Training developed in 1996 by the International Atomic Energy Agency [32,33]. It was applied in the company for the whole NPP fleet at national level. The aim of the SAT method is to identify what has to be taught in training sessions regarding each activity of each profession. To this end, professionals of the industrial trade and professionals of the training program (including the work analysts) met together and worked for several hours; they identified first the activities related to a profession; then for each activity they identified 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 French NPP fleet including 20 sites, for a complete achievement of the process, this resulted at least in a 2.2 to 4.4 man-days cost ((5 to 10) x (20+1) x (½)/24); integration of local feedbacks were not quantified.

2.5 Work Activities Analyzed

The SPEAC-based method was applied to analyze hydraulic configuration, Lock & Tag activities and periodical tests. These activities were chosen because the sponsor was expecting training improvement in these domains. As these activities constitute the main part of the work of Operations shift teams at the NPP, it thus increased the probability to find situations and voluntary workers to test the method.

Hydraulic configurations imply changes of equipment configuration used to carry fluids; the changes are necessary to adapt the industrial installation to safety or production requirements.

Lock & Tag activities are safety procedures ensuring that equipment is properly shut off and not started up again prior to the completion of maintenance or servicing work; it requires that a tag be affixed to the locked device indicating that it should not be turned on; the reverse operation is “unlocking”.

Periodical tests are sets of hydraulic and electric manipulations periodically undertaken by shift teams in order to test the reliability of the industrial process.

All these activities involve one worker in the control room (a pilot) and one worker in the field (a field worker): the pilot is in command of a lot of equipment in the control room, but there are many other devices in the field that need visual control or direct manipulations such as valves, ventilators, electric racks. Therefore, when a procedure requires changes involving pieces of equipment not linked with the control room, the pilot asks a field worker to take charge of the part of the work related to the field.

Over 8 weeks of shift, 21 situation cases were observed and interviews were performed individually with both co-workers and then collectively in order to confront their point of view. Among the 21 situation cases, 6 were rejected: 1 case because the activity was finally individual, 2 cases because of organizational issues preventing the activity to be achieved during the shift by the pair observed, 2 cases due to technical problem (therefore non-standard), and 1 due to a participant-related problem (see below).

One technical problem was due to the use of a mini SD card in the camcorder inserted through a standard SD card adaptor; the electric intensity of the camcorder was probably too high and consequently damaged the cards (we could not know whether it was a problem of camcorder or card); the other technical problem was associated with an inappropriate modus operandi delivered by the preparation team. The

participant-related problem was due to the attitude of a pilot: while performing the work activity, he made a mistake when checking the state of a pump on a control panel; this was clear during the pre-analysis when viewing his subjective video and comparing his action with what he said he indented to do just beforehand and what he said to the field worker just after the action; during his individual replay interview the field worker confirmed this analysis on the basis of what he remembered and of the video sequence related to this exchange. Nevertheless, during the individual replay interview, the pilot explained his action as if it had been intended, not as a mistake. The interview was thus shortened and related data rejected as the material obtained could not be considered reliable.

Finally, 15 situation cases were kept for the analysis phase involving 15 pairs of co-workers.

2.6 Self-assessment of the SPEAC Method

Following each analysis, subjects were presented with a 9-item questionnaire answered on a Likert scale for self-assessment of the method. Items addressed efficiency, constraints, extended application to colleagues or other activities. The questionnaire also helped us to collect socio-demographic data (age, gender, experience).

1- Do you think that analyzing the subjective film is a real added value compared to analysis without subjective film (i.e. a method said “classical”)?
2- Do you think you progressed regarding this work activity with this method?
3- Do you think you progressed regarding the work activity faster when applying the method than with a so-called “classical” method?
4- Do you find the method (miniaturized camera and subjective film analysis) constraining for you?
5- Do you think the method is innovative?
6- Do you think the method is difficult to apply by analysts?
7- Do you think the method is worth to be applied to other work activities?
8- Do you think the method permits to highlight particularities which are invisible with a so-called “classical” method?
9- Do you think the method has any interest to be applied to your colleagues?

Answers on the Likert scale were coded from –2 (strongly disagree) to +2 (strongly agree) and an average score was calculated for each question.

2.7 Subjects

Subjects were not designated or chosen as their participation was voluntary. During the shift briefing, activities of interest were selected and workers assigned to these activities were asked whether they agreed or refused to participate in the experimental application. They always agreed. Table 1 presents the average subjects’ characteristics.

Table 1. Subjects’ characteristics involved in the experimental application

	Field workers	Pilots
Gender (% male)	100	100
Age (years)	27.7	27.7
Experience (years)	6.1	1.8
Number of subjects	15	15

3. RESULTS

As presented in section 2.5, 15 situations involving 30 subjects were analyzed, representing about 1950 min. video recordings and 2400 min. audio recordings.

3.1 The SPEAC Method Compared with the SAT Method: Efficiency

Efficiency was assessed by averaging the number of knowledge and know-how identified by each method for a pilot and for a field worker per activity. Individual and collective knowledge and know-how were differentiated. The comparison was done through a ratio with the SPEAC method contribution as numerator and the SAT contribution as denominator. A ratio higher than 1 illustrated thus higher efficiency for the SPEAC method. The same was applied to compare the time spent to complete each method. Here, a ratio lower than 1 depicted a lower cost for the SPEAC method. Results are summarized in Table 2.

Values were calculated as for the previous study [19]: as explained in section 2.3, the average cost of the SPEAC protocol was 1.5 man-days for collaborative activities.

Section 2.4 showed that, when applying the SAT method, the cost was between 2.2 and 4.4 man-days. So as not to favor the SPEAC protocol, the lower value was selected for comparative calculation: 2.2 man-days.

Results in Table 2 related to real operating situations confirmed the results obtained in the previous study in simulated work situations [19]: the SPEAC method costs less and is more efficient.

3.2 Workers' Perception Regarding the SPEAC Method

The subjects' perception regarding the SPEAC method used for analyzing their work activity was assessed using the questionnaire presented in section 2.6. The Cronbach coefficient was α=0.75 for the field workers and α =0.60 for the pilots, showing a good consistency of the data. For the whole sample, α =0.66 also showed a good consistency of the overall data drawn on Fig. 2.

Analysis of the answers provided by the subjects to the questionnaire on a Likert scale coded from –2 (strongly disagree) to +2 (strongly agree) showed that, from the workers' standpoint:

- Analyzing the subjective film was a real added value compared to a method without subjective film (i.e. a method said "classic"): average score 1.55 with 100% ticking 1 or more,
- The method induced faster progress than with a "classical" method: average score 0.76 with 62% ticking 1 or more,
- The overall perception was positive (not constraining for them, innovative, worth to be applied to other work activities): average score 1.24 with 89% ticking 1 or more,
- The method had interest to be applied to colleagues: average score 1.31 with 96% ticking 1 or more,
- The method had interest to be applied to other work activities: average score 1.24 with 100% ticking 1 or more.

Table 2. Efficiency of the methods applied per activities

Activity / worker		Individual knowledge and knowhow	Collective knowledge and knowhow	Tacit knowledge and knowhow	Cost (Man-Days)
Hydraulic configuration	Pilot	8.5	23/0	Yes/No	0.7
	Field worker	6.7	23/0		0.7
Electric configuration (cell lockout)	Pilot	12/NA	24/NA	Yes/No	-
	Field worker	2.7	25/0		0.7
Periodical test	Pilot	1.9	25/0	Yes/No	0.7
	Field worker	9	24/0		0.7
Lock out (hydraulic config.)	Pilot	12/NA	24/NA	Yes/No	0.7
	Field worker	2.1	24/1		0.7

Comments: "NA" is Not Available; "5/0" means 5 items were found with SPEAC when 0 with SAT

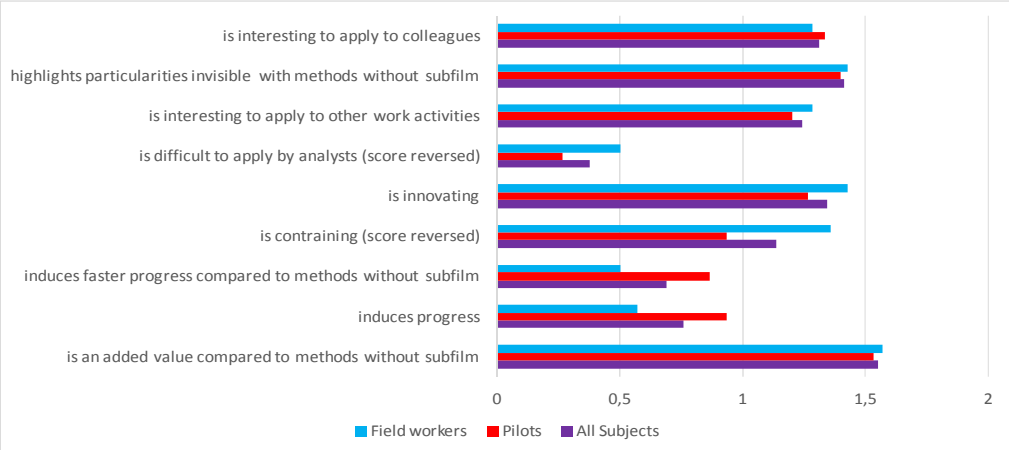

Fig. 2. Average scores for each question evaluating SPEAC method used for analyzing activities; assessment made by pilots and field workers

The average scores for each question for pilots and field workers is given on Fig. 2. Calculation of χ^2 showed that the pilots and field workers' distributions were similar: $\chi^2(1,fd=8)=0.76$, $p>0.5$.

4. DISCUSSION

4.1 The SPEAC Method Performance

Results obtained when using the SPEAC protocol were compared with other methods: in the present study, it was compared with the SAT method; in the previous study [19], it was compared with i) the SAT method, ii) the SAT method combined with a descriptive approach of the activity and iii) the self-confrontation method.

For all activities which were analyzed, the SPEAC protocol helped analysts to detect a higher number of explicit knowledge and know-how (from 1.44 to 17 times more), to detect tacit knowledge and know-how while not detected with other methods and it gave a 30% reduction in the cost of analysis. Therefore we may conclude that these first tests and applications showed a satisfying performance of the SPEAC protocol.

This reduction in cost was objectified at the advantage of the SPEAC method although the competencies of people involved in the work activity analyses were not taken into account. If this would have been done, the gap should have been even greater. Indeed Table 2 provides costs in terms of man-days regardless people's position or competencies performing the analyses. For the SPEAC method, a work analyst (with an academic background in Human Science and a technical experience) meets technicians in the field. For the SAT method, managers, experts in occupational training (including trainers and/or analysts with an academic background in Human Science and a technical experience) and technicians meet in brainstorming. Two aspects are worth to be highlighted here. The first aspect concerns the positions: the SAT method gathers more people with higher income than technicians whereas it is the opposite for the SPEAC method. This supports the fact that the gap in cost between the two methods is actually greater than what the assessment in man-days may provide. The second aspect concerns the competencies summoned for work analyses. The difference between the methods in terms of competencies is this of the managers and of the trainers which are effective at some steps of the SAT method while they are not used through the SPEAC method. This shows that, despite a higher diversity of competencies engaged for SAT-based analyses, the SPEAC method is shown to be more efficient than the SAT method. In addition it must be noticed that all competencies summoned for the SPEAC-based analyses are effective for the SAT-based analyses; this shows that the higher performance of the SPEAC-based analyses is not a question of analysts' competencies but a question of method.

When comparing the different methods applied, we assume that what makes the SPEAC protocol more efficient is the way it structures the interview questioning and also the way it forces the analyst to keep the four poles questioned in mind.

The outcome was to provide input data for training programs in terms of competencies to be developed by trainees. Therefore, as the SPEAC method reveals a high level of exhaustiveness in providing this data including tacit competencies, the subsequent training programs gain in efficiency. This provides an element of solution to the skills drain mentioned in section 1. This also means that the SPEAC protocol is only one step of the training curriculum building: the final success regarding training (usually assessed through workers' capacities at performing an activity successfully) also depends on other steps of this curriculum. If other steps are not appropriate or deficient, then providing relevant input data for the training program is useless.

4.2 Subjects' Perception of the SPEAC Protocol

When using the questionnaire presented in section 2.6, the overall results showed a positive perception of the SPEAC method both from the pilots and the field workers (Fig. 2). The answers to the multiple choice questionnaire did not give reasons for these perceptions but spontaneous comments at ends of RIW gave an insight of these reasons: they better understood what was done, they discovered bad habits like cutting off colleagues' speech, identified behaviors that should need corrections, were distantiated from the situation whilst viewing the subfilm thus providing a fresh perspective. In addition to these personal benefits, it contributed to enhancing the collaborative work and helped them becoming aware of unconscious good practices.

When considering the distribution of scores per questions on Fig. 2, the perception was similar

whether it be that of the pilots or the field workers ($\chi^2(1,fd=8)=0.76$, $p>0.5$). Even when there was a significant difference, the scores gave the same trend; for example, both pilots and field workers perceived the method as "not constraining": the mean score was about 1 for pilots and about 1.5 for field workers.

The important points are that:

- Participants found the method interesting to apply to other activities as well as to colleagues: this suggests that the subjects identified the usefulness of the method. This assessment is thus not only that of the management or of the researchers who decided to implement the method.
- The overall perception was positive (in particular "not constraining"): this suggests that the method might be applied to anyone in the Operations shift teams. However, this should be balanced with the fact that subjects participating to the research were all volunteers and that the study was presented as applying a method to identify the competencies of experienced workers. This induced a natural self-selection of participants: workers at ease with their profession enough to accept being exposed to the researcher through the RIW had no difficulty to accept participating. It is possible that workers less at ease or perceiving themselves "not competent" or "less competent" or having a problem of self-esteem would have given a less positive feedback.
- Despite the fact that the purpose of the method was to analyze the work activity for future enhancement of professional practices through training, subjects perceived their professional practices already improved during the RIW, especially pilots (mean score close to 1). This had already been noticed by researchers applying SEBE and involving subjects in RIW to analyze the work activities (see for example [5:22]).

In addition to these visible aspects of the subjects' perception (visible through questionnaires or spontaneous talks), we may assume that, despite this was not said, the interest shown to subjects for their work activities was another positive point.

All these elements lead to assume that implementing widely the method throughout an industrial plant might not encounter objection from the workers.

4.3 The SPEAC Protocol Limits

The SPEAC model is based on the subjects' perception of factors related to their competencies: this provides a subjective description of knowledge and know-how which constitute and contribute to their competencies. This description may thus be altered by the recall process or by the incompleteness of the subjects' report. This bias cannot be avoided as competencies may only be effectively observed in action and as this is underpinned by what the subjects have in mind, the recall of which is necessarily imbued with subjectivity.

Nevertheless, this bias can be lessened. The SPEAC protocol is relying on the first-person video recordings of competencies in action and as pointed out by Luff et al. [17:6.3], this approach may 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". In parallel, the contribution of the analyst provides a distanced view on the activity: as for other methods (self or cross-confrontation, SAT method, description-based method; see previous study for description of these methods [19]), the confrontation of the subject and analyst's viewpoints contribute to lessen the subjective dimension of the collected material through questioning, one of the aims being to relate facts to the subjective descriptions.

However, depending on the goal of the analysis, it is not injudicious to consider the results provided by SPEAC protocol on the unique basis of the subjective description of the activity, even if it is incomplete. For example, since the SPEAC model is presented as describing the necessary conditions for the subject to put successfully competencies in action (section 2.3), any weakness of the structure described by the model applied to an activity highlights and contributes to understand the problem encountered.

To illustrate this, let us consider a manager asking an employee to provide a work of quality (part of *Having to act*) and the same time, limiting the time allocated to do this work (part of *Having to act*). If this time is too short to ensure the required quality of the work, these two parts of

Having to act are not coherent, giving contradictory injunctions and thus competencies cannot be put successfully in action. This incoherence within the pole *Having to act* makes it difficult to put competencies successfully in action. Applying the model to this situation helps the analysts to characterize the psychological issue for the subject, here incoherence within the pole *Having to act*. It also helps the analysts to try to find a possible solution to this issue: may the pole *Being able to act* provide compensatory resource in terms of means, by providing more performing tools for instance? Incoherence within the pole *Having to act* refers to a static approach and considering the interpolar relationship between *Having to act* and *Being able to act*, this refers to the dynamic approach; this short analysis is undertaken without the necessity to describe completely the activity or the competencies in action for this activity. In this case, the model is used as a tool that may provide a fast, objective and determinant identification of psychosocial risks and associated remedial measures (see an example of application in [34]): indeed, the model can contribute to explain why, in certain occupational contexts, workers may experience psychological difficulties possibly deteriorating their mental or express a restriction syndrome and "double-bind" [35].

4.4 Risks Encountered Applying the SPEAC Protocol

In section 3.2, when presenting the subjects' perception regarding the protocol applied, it was found that the SEBE equipment was unanimously accepted by subjects. Yet, other experiments [21,22] showed that precaution had to be taken regarding potential problems induced by the SEBE equipment for subjects. Hence a risk assessment is recommended for any type of SEBE methods before application to any real operating situation. This was applied in the present study on the basis of previous works [19-22] and using the risk assessment form available for free online at http://hayka-kultura.org/larsen.html.

5. CONCLUSION

The results obtained let us conclude that the Square of PErceived ACtion protocol (SPEAC protocol) integrating the goal oriented replay interview is an efficient method to identify knowledge and know-how that makes competencies of experienced workers. Compared to three other methods widely used, knowledge identification is more complete (making it a powerful tool that will help industrials to improve their occupational training program) and has a lower cost in terms of time spent and people involved (making it an interesting investment for companies). This was demonstrated for simulated work situations in a previous study [19] and for real operating situations in the present study. As the SPEAC method reveals a high level of exhaustiveness in providing data regarding competencies including tacit, the subsequent training programs gain in efficiency. This provides an element of solution to the skills drain mentioned in "Introduction".

We suggest all companies concerned by the phenomenon of skills drain could benefit from the method presented here to improve their professional training. Three key points make the SPEAC protocol of interest: its efficiency at detecting knowledge and know-how, its low cost and the good worker acceptance.

The applications presented here as well as those in the previous study exclusively concerned technical activities in industrial contexts. However we postulate that the method could be similarly applied to any other kind of work activities including managers' activities or office work. This offers a new field for experiments.

The main limit of the method might resides in the nature of the knowledge and know-how identified: they are provided through the subjective prism of the workers; however, we showed that this might be greatly lessened by the fact that the method relies on the use of first-person perspective video of the activity: the subjective matter is based on objective matter.

For future research, areas for improvements may be addressed regarding at least two domains: technical and methodological. For the technical domain, reducing the bulk of the equipment (already small) will be welcome and withdrawing cables without introducing a problem of electromagnetic interferences with the industrial control-command is an current challenge. For the methodological domain, training the analysts to apply the SPEAC protocol might be another challenge. Amusingly it might imply using the SPEAC protocol to analyze a SPEAC-based activity analysis.

CONSENT

Written informed consent was obtained from participants 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

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