

The Improvement of Safety Rules by a Participatory Method. A Case Study in a Chemical Company

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Safety management in high-risk systems is based on safety rules that have to prescribe human action and interaction and should reduce errors and risks.

The present case study want to report an organisational intervention aimed to improve a Safety Work Permits System (SWPS) in a chemical company through the employees' involvement which daily use this system. SWPS consists in a step-by-step process designed to ensure that hazardous work activities could be performed in a safely way. The organisational intervention comprised 20 focus groups (190 total participants), whose main aim was to work on the current SWPS with the final aim to improve them. Employees with the help of experts analysed the SWPS and suggested improvements on the basis of three main phases: before the SWP filling, during the work activity and after the task accomplishment. Before and after the sessions a questionnaire was administered to participants in order to collect data on their opinions and perceptions about safety procedures. The participants noted some criticism in the SWPS and proposed solutions to enhance the system therefore eliminated the met problems. As well as improving the system we have also shown that workers involvement and active participation has resulted in an increased acceptance of safety rules included in SWPS.

1. Introduction

With the aim to enhance occupational health and safety in the workplace, companies usually implement organisational interventions, which could be defined as 'planned, behavioural, theory-based actions that aim to improve employee health and well-being through changing the way work is designed, organized and managed' (Nielsen, 2013, p. 1030). In order to be effective, employees should be involved in the planning and implementation of organisational interventions (Nielsen, Randall, Holten, and Rial González, 2010), owing to the fact that the worker's rule perceptions are antecedents of safety behaviors (VinodKumar and Bhasi, 2010). This paper focuses on an organisational intervention aimed to improve a Safety Work Permits System (SWPS) in a chemical company through the employees' engagement who daily use this system.

Safety Work Permits System (SWPS) consists in a step-by-step process designed to ensure that hazardous work activities can be performed in safety. Especially in chemical companies, that have to deal with high-level safety risks, safety work permits can play a major role in decreasing occupational hazards. SWPS is used every time an employee has to perform work activities which are not ordinary, thus require a dedicated risk assessment. Generally, SWPS concerns maintenance and provide checklists which collect data regarding safety equipment to wear, procedures to follow etc. SWPS, like general safety rules, outlines three functions as means for organizational control (by reducing freedom of action and providing safety solutions), as coordination mechanism (by defining responsibilities for safety tasks), and as codified organizational knowledge (worker can learn by developing and applying safety routines for solutions).

Safety management in high-risk systems is based on safety rules that in the form of rule books, checklists, or procedures, are profuse in industries like power generation, aviation, transportation, medicine, and others like,

for example, chemical industries. Safety rules, in virtue of prescribing human action and interaction (with other individuals as well as with machines), should reduce errors and risks (Weichbrodt, 2015).

Hale and Borys' (2013) recognized a certain (inevitability) of rule violations attributing the causes for rule violations, for example, to the rule followers (lack of discipline, conscientiousness or diligence) or to the work context (lack of knowledge, lack of correct tools, pressure to produce, etc.).

One of the most important strategies for good rule management, and so for the prevention of rule violations, is the employees' participation in rule creation and adaptation (Weichbrodt, 2015). Research on participation in rule creation has only recently begun. On the same track, the present research wants to describe a process of an improvement of rules for safety in a chemical plant (specifically SWPS) and to show the initial results of the changes in workers attitudes towards safety, in particular regarding the perception and acceptance of safety rules.

1.1 The safety rules

Safety rules can be considered as organizational artefacts that require interpretation and "translation" into behavioural actions (Weichbrodt, 2015). Every artefact can be interpreted both as instruments and as symbols. Instrumentality regards the usefulness of an artefact, that in the case of safety rules, is probably the most important one (rules are generally seen as instructions on how to perform a task in a safe manner). The symbolic dimension of artefacts shows their meanings and messages.

To study the perceptions of SWPS, as artefacts, we have adopted one of the most used model for analysing of acceptance and adoption of IT artefacts, the Technology Acceptance Model (TAM), devised by Davis (1989). Davis's Model is based on Martin Fishbein and Icek Ajzen's Theory of Reasoned Action (Fishbein and Ajzen, 1974). TAM explains that the Perceived usefulness (PU) and Perceived ease of use (EOU) of an artefact are predictors of the user's attitude towards its implementation and adoption. This attitude then, in turn, affects the user's intention to introduce an artefact and subsequent behaviours. Intention is a proximal predictor of behaviour in Fishbein and Ajzen's Theory of Reasoned Action. In our prospective, perceived usefulness is the extent to which a person believes that following the SWPS rules will enhance his safe performance and Perceived ease of use is the extent to which a person evaluates the effort they will put into following the rules. To sum up, the PU shows the instrumental dimension of SWPS and EOU as the symbolic dimension of SWPS.

To analyse the perceptions of SWPS it is essential to consider the individual importance of safety in the workplace. So we have contemplated the safety motivation that could be described as an individual willingness to exert effort to enact safety behaviors and the valence associated with those behaviors (Mariani, Soldà and Curcuruto, 2015). Following the Griffin and Neal model (Toderi et al. 2015), safety motivation has an important role in human factor as, together with knowledge, determines the individual safety performance of a worker. On the other hand safety motivation is directly influenced by a safe climate that refers to workers' shared perceptions of their firm's and their leaders' approach to safety (Toderi et al. 2015).

Self-Determination Theory (SDT) is a popular psychological theory of human motivation and behavior which outlines different types of motivation. The starting point of the theory is the concept of self-determination. To be self-determining means experiencing a sense of choice in initiating and regulating one's own actions. Based on this concept SDT proposes two overarching types of motivation: extrinsic and intrinsic. Extrinsic motivation means doing something for instrumental reasons, intrinsic motivation means doing something for its own sake. These two different aspects reflect two different strategies for improving safety in workplaces: behavioral-based safety initiatives and safety culture strategies. Behavioral-based safety programs largely focus on motivating employees through contingencies (e.g., rewards), whereas developing a positive safety culture is more value-based and focuses on encouraging employees to internalize the value of safety. In this second strategy we can include the safety intervention presented in this work.

1.2 Organisational Safety intervention to improve Work Permits System (SWPS)

The intervention was carried out in an Italian plant of a chemical company. The plant, where 280 employees work, is specialized in the realization of plastics additives that fall into the category of light stabilizers and antioxidants. The plant production is developed in two synthesis unit and supported by two laboratories, an engineering department, a supply chain and logistic department, and an environment-quality-health-safety department. The main clients of this industrial production are in different markets as in automotive, agriculture, building and construction, electrical and electronics, fiber and textile, packaging and consumer goods.

The intervention was developed within a safety performance program that, on the basis of a periodical analysis, gives both continuous and specific improvements to its own activity in the safety environment. According to this, the main aim of the intervention was to improve an existing safety work permit system (SWPS) by updating and involving the workers. In general, the project evaluated: interviews with managers, focus groups with workers (which actually represent the intervention described below), and finally workshops to define the improvements of SWPS.

The focus group is a qualitative research method in which a group of people are asked about their perceptions, opinions, beliefs, and attitudes towards a product, service, concept, advertisement or idea. Focus group methodology is a qualitative data gathering approach that takes advantage of structured interviewing techniques performed in a group setting. Unlike more traditional one-on-one interviewing, the focus group approach encourages discussion among group members, and this interaction tends to stimulate ideas and to present suggestions and improvements that would not have been available otherwise (Morgan, 1988). The dynamic interplay generated among group members can provide rich, descriptive information offered from the respondents' viewpoints. Questions on SWPS were therefore asked in an interactive group setting where participants were free to talk with other group members.

The focus groups were organized in order to highlight the critical aspects of the current SWPS and improve them. In other words, with the help of an expert the employees analysed the SWPS and suggested improvements referring to three main work activity phases:

- 1) before the work activity start (i.e. job analysis, risk assessment and protection tool compilation, safety check, SWP opening signatures),
- 2) during the work activity (i.e., monitoring of SWP use) and
- 3) after the work activity accomplishment (i.e. work-finish notice, safety checks, SWP closing signatures).

Furthermore, before and after the focus group sessions a questionnaire was administered to participants in order to collect data on their opinions and perceptions on safety procedures.

1.3 Participants

Chiefly, 20 focus groups were organized, each focus group lasted 135 minutes and involved about 10 participants for a total of 198 participants belonging to 4 different company areas. Furthermore, the employees participation in a specific focus group occurred within their own company area.

Of the 198 employees who were involved in the project; almost 54% were supervisors for safety and 58% were in teams of emergency. Only 7 of the participants were female and the mean of work tenure was 17.4 years.

1.4 Questionnaire

As mentioned above, the methodology included the filling-in of a questionnaire before (T1) and after (T2) every focus group, which was put together as follows.

The original scales devised by Davis (1989) were adapted to assess the two TAM constructs of SWPS: Perceived Usefulness by three items and Perceived Ease of Use by two items. These measures showed high Cronbach alpha reliability levels (the indexes usually exceed 0.90) and a high degree of convergent, discriminant, and nomological validity in numerous studies. These scales also have good alpha coefficients in this research (PU at T1= .80; PU at T2=.79; PU at T1= .79; PU at T2=.83).

The motivation constructs were measured with the Italian version of SDT scale developed by Mariani and colleagues (2015). Both constructs, extrinsic and intrinsic motivation, were measured by specific four items. These scales have good alpha coefficients in this research. (EM at T1= .69; EM at T2=.76; IM at T1= .81; IM at T2=.85).

Moreover the questionnaire had two questions: one on the WPS Effective in preventing accidents and the other on Risk perception when WPS is adopted.

1.5 Results

The main critical issues found on SWSP during focus groups by the workers involved are shown in Table 1.

Table 2 shows differences in the participants' perceptions before and after the intervention concerning safety work permits. Results showed that for all of the variables investigated (except for "useful for the company") there is an overall increment after the intervention. Specifically, safety work permits after being modified during the intervention results clearer, easier to use, more useful for users and safety performance and more effective in preventing accidents. Furthermore, concerning risk perception, workers reported lower levels after the end of the intervention in respect to how likely they thought accidents could occur after safety work permits had been modified.

Additionally we investigated whether workers' motivation could influence the perceptions on safety work permits. Regression analysis (table 3) showed that only intrinsic motivation is able to predict levels of safety work permits measured at the end of the intervention.

Multiple correlation coefficient was .10 for regression analysis with PU as dependent variable and .09 for regression analysis with PEOU as dependent variable

The *F*-ratio of ANOVA tests whether the overall regression model is a good fit for the data. The results shows that the independent variables statistically significantly predict both the dependent variables: PEOU $F(2, 186) = 10.03$, $sig. = .000$; PU $F(2, 186) = 10.23$, $sig. = .000$.

Table 1: Main critical issues on Safety Work Permit System

Phases of work activity	Phases of SWPS	Criticisms
Before	Starting notice	The notices are written superficially and do not contain details about problem
Before	Preliminary Analysis	There is quite a role conflict about work description fulfilment.
Before	Coordination meeting	Coordination meetings are not profusely attended.
Before	Risk Assessment and safety provision /DPI	Need to facilitate the risk assessment activity
Before	Safety check	Need to standardize the safety check
During	Work permit check	In time difficult to check each work permit
During	Department notice	People of departments do not know what contractors are doing on the basis of work permits
After	Final work notice	Disrespect of communication procedure
After	Redelivery safety check	Lack of an activity list able to insure safety on the plant
After	Closing signatures	Lack of clarity on signature sequence

Table 2: Mean differences between before and after the focus group concerning safety work permits and risk perception

Variables	OLD SWPS		NEW SWPS		t	P
	M	s.dev	M	s.dev		
Clear	2.93	.66	3.23	.69	-4.34	.000
Easy to use	2.96	.71	3.19	.74	-3.34	.001
<i>EOU scale</i>	<i>2.94</i>	<i>.61</i>	<i>3.21</i>	<i>.66</i>	<i>-4.34</i>	<i>.000</i>
Useful for users	3.43	.86	3.62	.79	-2.52	.013
Useful for company	3.98	.70	3.91	.76	1.18	.239
Useful to safely performance	3.68	.89	3.92	.79	-3.29	.001
<i>PU scale</i>	<i>3.70</i>	<i>.68</i>	<i>3.82</i>	<i>.66</i>	<i>-2.17</i>	<i>.032</i>
Effective in preventing accidents	3.55	.82	3.82	.76	-4.18	.000
Risk perception when WPS is adopted	2.23	.67	2.11	.56	2.09	.039

Table 3: Effects of motivation on opinions about safety work permits

Dependent variable	Independent variables	B	SE	Beta	t	P
PU (T2)	Extrinsic motivation (T1)	-.01	.06	.01	-.16	.869
	Intrinsic motivation (T1)	.30	.07	.31	4.38	.000
PEOU (T2)	Extrinsic motivation (T1)	-.04	.06	-.04	-.60	.546
	Intrinsic motivation (T1)	.32	.07	.32	4.46	.000

2. Discussion

As formerly mentioned, worker's rule perceptions are antecedents of safety behaviors (Vinodkumar and Bhasi, 2010) and the effectiveness of the interventions is influenced by the involvement of employees in planning and implementation (Nielsen, Randall, Holten, and Rial González, 2010).

Therefore in this work we have shown an improved intervention of the Safety Work Permits System which involved employees within the focus groups. Probably our results may be also affected by the considerable amount of hours that the company invests in safety training (about 3000 hours per year); indeed this attention in safety training can contribute to make the workers feel more involved in safety outcomes.

The participants noted some criticism in the SWPS (e.g. Coordination meetings were not clearly attended) and proposed solutions to enhance the system therefore eliminated the met problems (e.g. Set up the coordination meeting in the production site).

As well as improving the system we have also shown that workers involvement and active participation have resulted in an increased acceptance of safety rules included in SWPS.

Using the Technology Acceptance Model (TAM), devised by Davis (1989) as a theoretical framework, we found that the workers showed a Perceived Usefulness and Perceived Ease of Use at a higher level in the

new SWPS (developed with their contribution) than in the old SWPS. Moreover after the organisational safety intervention workers believed the new SWPS to be more effective in preventing accidents and the risk perception to be higher.

Finally, confirming that the presented intervention can be considered a strategy to develop a positive safety culture and encourage employees to internalize the value of safety, our results underline that only intrinsic motivation affects the workers perception on the safety rules included in SWPS.

In conclusion, it is important to consider some limitations related to the study design and measurement when interpreting these findings.

First, pre post intervention evaluation was based on self-report measures, raising questions on the influence of social desirability. Consequently, this implies a certain risk that the findings may be based on common method variance.

Even if Perceived Usefulness and Perceived Ease of Use are most commonly and reliably captured through self-report, assessing acceptance of safety rules through different methodologies (such as actual observations, open-ended interviews, and behavioral index) will provide additional insights. Therefore, future studies should include both qualitative and quantitative measures as suggested by Vignoli, Punnett and Depolo (2014), and, if possible, the collection of data from other actors in the workplace (e.g. safety manager). The present study has been conducted in only one plant of a chemical company, thus results could not be largely generalized. Thus, the intervention proposed should be tested also in other sectors or in other types of companies in order to provide a general validity of the approach presented.

Literature concerning safety intervention effectiveness shows that outcomes should be measured in terms of knowledge, attitudes and beliefs, behaviours and health (Burke et al., 2006). In this work the results show the attitude and belief changes (in particular the acceptance of the relative rules on safety and the intent of their application) after intervention. These findings can also be read in line with the model of workplace training interventions for primary prevention in OHS developed by Robson and colleagues (2012). Between immediate outcome of intervention, this model cites, for example, reaction to training, knowledge, belief, skills, attitudes, motivations to act, behavioral intent. These immediate outcomes potentially impact on job behaviours and hazards, which in turn affect outcomes measured in the longer term, such as workplace injuries and illnesses. Therefore our results although preliminary, as they actually refer to immediate outcomes (in particular belief, attitude and motivation to act) which, however, represent a significant pre-condition to improve safety in the workplace in the long term.

3. Conclusions

The most important result of this work is that, not only the rules were improved, but also that people change their SWPS perceptions and their acceptance of safety rules related to the system after the intervention presented here, in which workers were involved and participated in the improvement of the system itself. This result confirms that the participation of workers in safety, in addition to the legal normative perspective, which can be traced in laws (in Italy for example expressly invoked by the Legislative Decree 81/2008) should also be analysed from the perspective of organizational management.

The participation in the rule creation process can increase psychological ownership of rules and positive interpretation of them. Moreover this bottom-up process can turn “wrong routines” (i.e., routines incorporating disallowed but necessary violations) into “correct rules” (rules that cover the actual, adequate routines) (Weichbrodt, 2015).

This focuses on the role of “active citizen” and workers “proactivity” on maintenance and improvement of safety at work (Curcuruto, Guglielmi, Mariani, 2014) This article, moreover should be used as an example for the implementation of safety intervention in line with the research on safety rules and rules management. According to Weichbrodt (2015) intervention and its evaluation, as shown in this paper, underlined how safety science, by taking a broader perspective, can gain from organizational theory.

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