Behavioral reinforcement to enhance safety performance at a Petrochemical Complex

By

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Abstract

A free accident industrial environment depends highly on the commitment of managers at pursuing excellence in QHSE standards (Quality, Health, Safety and Environment). Significant deviations from such standards are a reflection of a faulty management system, or else, a misconception of the nature of human error (e.g. placing a higher weight at individuals rather than a more systemic approach); thus not addressing the appropriate corrective actions. Herein, results of a project are discussed, where team building techniques were applied aiming to improve risk perception and the overall safety performance at a Petrochemical Plants managed by *Petrobras Energía* in Argentina. A conceptual model was developed and applied with the objective of reinforcing proactive safety behaviors, particularly oriented towards the top managers, later cascading their leadership to the rest of the organization. Measurements of their perception on safety habits, before and after the application of a sequential team building process, were documented and statistically analyzed, providing sound basis to suggest the usefulness of such an approach for achieving sustainable results.

1. Introduction

Accidents are one of most fearsome occurrences faced by industry, regardless of the size of operations or any other condition associated to production activities. Companies, nowadays, can not afford to cope with the result of a miss care in managing safety, mainly because it impacts its most valued resource: People. Thus, a great deal of effort is being placed at constructing management systems that would provide the operations with the necessary strength for building reasonable control capabilities to avoid deviations from the established safety standards (Stranks, 1994; Petersen, 2003).

Once a management system is in full operation, there is no guarantee that the occurrence of accidents will come to an end (Roughton and Mercurio, 2003). It is true, that system components provide the means by which deviations from Quality, Health, Safety and Environment (QHSE) standards are given an appropriate treatment for corrective actions but, in light of current international norms (e.g. ISO 9000-2000 and 14001 series; OHSAS 18001), sustainability can only occur by means of continuous improvement (Weinstein, 1996; Asfahl, 2003). However, the very heart of such maxima is the realization that there is a persistent need to search for innovations, due to the fact that operations are a never-ending source of variations in which the human factor is, by all means, its main driver (Sutherland, et. al., 2000; Petersen, 2001).

Given the importance human factor has on the sustainability of a good safety performance (i.e.. lowering significantly accident rates), companies are developing tools to improve its social dimensions procuring to enhance the activism and consciousness of their employees in matters related to a healthier and safer working place (Petersen, 2001; Davies, et. al, 2002). *Petrobras* has designed a QHSE management system mainly driven by two complementary processes which are categorized as follows: a Quality Program for Managing Excellence (through standards set by the National Quality Prize) and a Process Safety Management (PSM) Program, which is a comprehensive set of standards and systemic actions conceived to align operations to Corporate policies, seeking to achieve a world class performance in Health, Safety and Environment (HSE).

This later category (PSM) involves developing observational skills within the population of employees, starting from top-level managers, down to the entire line of supervision. The main difficulty to establish such cumbersome task resides on the resistance to changes, perhaps due to the cultural structure of values already present in the minds of supervisors, leaders and operators, as a whole. Breaking believes or, preconceived notions, is not an easy task, requiring more than Corporate commitment to follow a sequence of actions, usually difficult to achive (DuPont, as a good example, Hansen, 2000).

This paper deals with an experience developed at two Petrochemical Complex of *Petrobras Energía* in Argentina, where the top members of their management teams went through a process of safety behavioral reinforcement, using

conventional team building, coaching and risk perception techniques. The approach, followed a “360 all around” involvement, which included the follow up of the perception of self, supervisors, peers, friends and family members on safety-geared behaviors. Results were so promising, that this experience is now being expanded to other sites and operations of the company, as a valuable tool to accompany various actions of the existing QSHE Management System in order to induce the sustainability of reduced accident rates.

2. Methodology

The Behavioral Reinforcement Project (BRP) was mainly designed for the leading team members; under the bases that line supervision is, ultimately, accountable and responsible for the safety performance of the operations (Petersen, 1996). Thus, a cascading effect was aimed by the empowerment of the leading team members once the main objective was fully covered: A commitment to safety and its conscious incorporation into their personal habits (Geller, 2000).

The BRP was designed from the following conceptual framework, depicted in Fig 1:

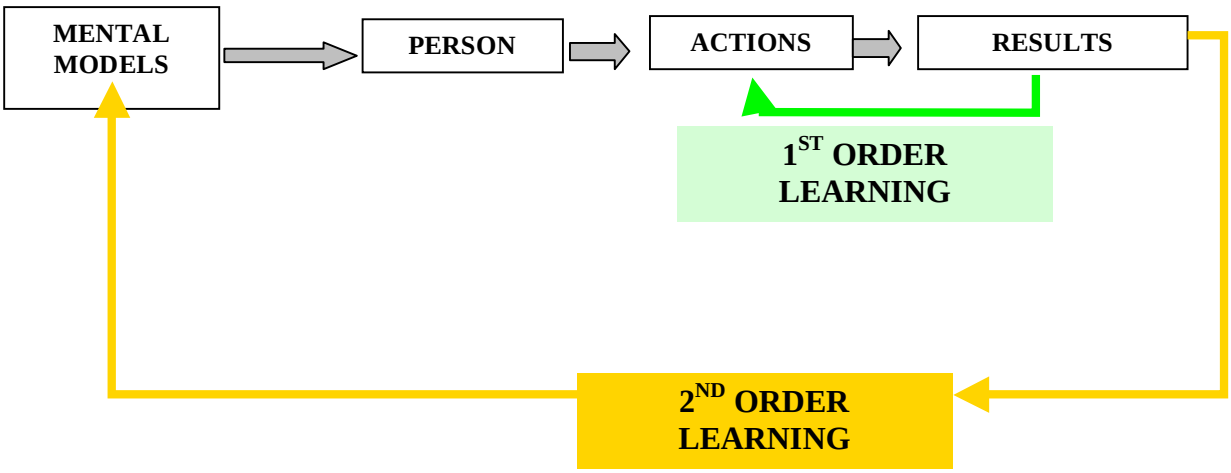

Fig. 1 Mental models and learning processes

That is, individual's believes are directly related to people's mental models, which in turn, are the result of their cultural background (including their learning's through their life's histories). Given a particular situation, a person acts in agreement with his/her mental model, thus producing a result. In regard to safety procedures, if the resulting solution is not later processed, as to enhance the performance of the overall system (a process here called "Secondary Order Learning" – Fig. 1), then there could be a tendency towards a recurring failure, because of a lack of understanding of the actual problem (this unreflective process is here called "Primary Order Learning – Fig. 1); thus never producing long lasting adequate solutions. The desire of the BRP was to produce an increasing safety perception within the leaders of the operations, such that, their leading capabilities would be able to persuade others, towards the adoption of appropriate long lasting solutions during their daily performances; solutions that, if possible, could become part of the management system, created to prevent accidents.

As a simple, but illustrative example, let us consider the finding of a missing or broken stepladder. The usual tendency would be to proceed for a replacement, without any further consideration. However, unless there is a more thorough inspection of the ladders and their structural conditions, there could never be an understanding that, for instance, there is a major corrosion problem affecting, not only the stepladders, but also some other critical structures regularly used within the operations. The later approach to the problem is the basic desired premise of our BRP, in regard to the safety of our operations.

2.1. BRP phases

The entire BRP process, can be summarized into four phases:

- **Creating awareness -** : A mix of outdoor and indoor activities using traditional team building techniques to reinforce the need for mutual cooperation and alignment to the leader's views towards a better safety performance. Key to success was the selection of audiovisual material with good motivational contents.
- **Analysis and reflection:** Individual and group meetings were set to establish expectations in regard to the project and evaluate the sensibility of the group towards safety (Geller, 2000). This phase ended up by presenting a questionnaire designed to measure perception of safety habits in the following contexts: A) Working environment: self, peers and boss, B) Personal Environment: self, family members and friends. The questionnaire had a feedback time of one week, and its results were considered as the initial measurements.
- **Implementation of an action plan**: Homework related to increasing safety habits at work and at home was agreed upon, with each team member. Later, a coaching process was designed by which individual tasks were analyzed, allowing for further development of a an action plan with a deeper scope, having the safety of operations as a framework, but also emphasizing the importance of applying safety habits at home or any other daily activities.
- **Evaluating results**: Team members were created a task-related objective tables, which also served as a measure of their advance through their individual

and collective action plan. The same questionnaire of the first phase (Creating awareness) was administered at the end of the six months of the project, following the same procedures as described above.

2.2. BRP Data acquisition and Analysis:

The main measured characteristic was the perception towards safe, as gather through the basic questioners that were administered at the first and last phases of the BRP. For instance, in regard to the use of safety belts while driving, the person had the choice of selecting from a lowest "never used" (measured as 0 points) to a highest "always used" (measured as 4 points). Between these extremes, there was the choice of "very rarely used" (scored as 1), "only used under certain conditions" (in freeways, in long journeys, etc.; scoring 2) and "used frequently, but not always" (scoring 3). The answers to twenty such questions were added up, giving an overall score on percentile bases.

These measures of the perception on safety habits among the leading operation members, were analyzed according to the following:

- **The questionnaire**: It dealt with issues in five different contexts: a) Frequency in driving habits, such as: Use of seat belts, asking others to use the seat belts, parking backwards, observe driving signals, use of cellular phones, etc.; b) Frequency of healthy habits: care in food choices, physical exercises, periodical physical examinations, etc.; c) Frequency in home safety habits: care with electrical equipments, stepping and handling

precautions, etc. d) Frequency of safety working habits: risk evaluation precautions, following safety procedures, detection of unsafe acts, etc. e) Frequency of outdoors habits: protection to sun exposure, use of appropriate weather clothing, warning others of risks, etc.

- **Statistical comparisons**: Data on the perception of safety habits were compared before and after the application of the five steps of the BRP sequence. Comparisons were made using the following statistical approach (Zar, 1999):

  a. Initial and final Overall Perception: Wilcoxon tests were applied to compare self-perception between initial and final phases at the personal and working environments. The same approach was used for comparisons between the perceptions of "others" (boss + peers at the working environment and family + friends at the personal environment).

  b. Within the initial phase: Kruskal - Wallis tests were applied to compare perception at the working environment (self + peers + boss), as well as perception at the personal environment (self + family + friends).

  c. Within the final phase: Application of Krukal – Wallis tests, similar to "b", but with data generated from the final questionnaire results.

3. Results and Discussion

Wilcoxon test comparisons for self-perception of safety habits between initial and final phases of the BRP process, resulted in highly statistical significant differences when applied to data from evaluations at the personal environment ($Z = -3.307$, $p < 0.001$, $n = 14$), and at the working environment ($Z = -3.186$, $p < 0.001$, $n = 14$). These results provide an indication of a conscious recognition of changes within the individuals in regard to their perception towards risks. In general, self-evaluations on both tests (working and personal environments) yielded higher results at the final phase, which could indicate the influence of the BRP process as a contributor to enhance safety habits.

However, this idea needed to be reinforced by analyzing data coming from the perception of “others”, under the basis of a more objective perspective. At the working environment, the combined analysis of boss + peers yielded highly significant differences ($Z = -2.658$, $p = 0.008$, $n = 28$). In addition, analysis of personal environment data (family + friends) showed a similar trend ($Z = -3.778$, $p < 0.001$, $n = 28$). Thus, there seems to be consistency in these results since the safety habits of the individuals involved, as perceived by “others”, also gave higher evaluation values at the final phase of the BRP process.

It was also important to analyze in more depth, the data from the initial and final phases separately, in order to sort out the sources of variations. When doing so, a Kruskal – Wallis (K-W) test (self + peers + boss) revealed highly statistical

significant differences for the initial phase of the BRP process at the working environment (χ^2 = 12.629, p = 0.002, n = 42). Application of a Dunnet's multiple comparison test indicated that these differences were mainly attributed to the supervisor's perspective ("boss"), which had an initial tendency to evaluate their supervised personnel with lower scores than self-evaluations ($p < 0.01$). Interestingly, self and peer's evaluations did not show significant differences (p = 0.975).

The final phase results for the working environment data, as tested by a K-W analysis, yielded no significant differences between self+boss+peers (χ^2 = 0.813, p = 0.666, n = 42), which means a change in perception, particularly attributed to a shift in the supervisor's ("boss") perspective, now pretty much in line with their supervised personnel's self view towards safety habits.

At a personal level, K-W group comparisons (self + family + friends) gave no significant statistical differences at both, initial and final phases of the BRP process (Initial phase: χ^2 = 1.404, p = 0.496, n = 41; Final phase: χ^2 = 0.423, p = 0.809, n = 41). These are revealing results, since they indicate an expected better knowledge of the individual's perception, within their personal environment.

The later analyses provide a framework for understanding the factors associated to changes in perception of the individual's most influential environments: the personal and the working environments. It is no coincidence that a team building

approach, but highly aligned to the desired safety performance, was meant to direct influential perception changes in the leading team members. Geller (1997) has discussed extensively of the value of applying team-building techniques in order to provide sound bases for behavioral changes in safety perception. The personal environment, constituted by family and friend members could be viewed as a rather “naturally” constructed team, which are generally prompt to know better the individual’s behaviors. By inference, it could be said that the leading team members subjected to the BRP process were benefited by this team building approach, since not only their perception towards safety was increased, but there was also construction of a more homogenous understanding of their mutual perception.

Intervention at an operational level, focusing on a behavioral approach towards safety has been explored and documented extensively in the literature (Komaki, Barwick and Scott, 1978; Sulzer-Azaroff, 1982; Geller, 2000). A conceptual framework based on behavioral reinforcement through team building techniques is also a resource strongly recommended (Petersen, 2001; Davies et. al 2002), but should be taken with care because its sequence must be molded into the context of the organization for which the project has been conceived. In the particular case being treated here, the Petrochemical Complex had a management system already in place with a certain degree of maturity; therefore, the design of the project was meant to fit into their needs (Reese, 2003), rather than to create a system in itself. Thus, in cases where the organization is not fully understood, it is critical to open an appraisal phase, and the results of such previous work will dictate the best

approach or techniques of application (Geller, 1996, Roughton and Mercurio, 2002). There could be situations in which the organization has not fully developed a QHSE system and thus, the project could contain the actual design of a management system addressing behavioral based elements, as discussed by Ugalde and Dasencich (2000) for a case study at a Chilean mining company.

In regard to the recent history of accidents in the referred Petrochemical Complex, it becomes evident that there has been a positive impact on safety performance during the passed few months, clearly reflected in its indicators. The Loss Time Incident rate (LTI, using ANSI standards) for year 2003 was estimated in 2.01. By august 2004, at the peak of the accident increment, the LTI was estimated in 4.26 (the year closed with an LTI of 2.75). More than two years since the beginning of the BRP process and other preventive measures, the total reported accidents in this Petrochemical Complex has remained zero (over 5 million man-hours).

Personal and group commitment towards safety is a very difficult task to achieve in a working environment when the cultural basis of production is usually dominated by business driven interests. The need for creating a conscious evolution towards the inclusion of safety performance within business objectives is expanding throughout Corporations. In this regard, the prospects of applying methodologies with an orientation aligned with human sciences is becoming a first industrial choice, when there is a commitment to build firm basis for safety management and achieve its sustainability (Petersen, 2001; Davies at. al, 2003). Although the BRP process was not an isolated project since, on the contrary, it was designed to

complement many other actions associated to safety performance improvement, results herein provide an encouraging indication of the usefulness of such an approach. A similar project is already underway at another of Petrobras Petrochemical Complex, having gone through the first phase, obtaining, so far, similar statistical results, in which the supervisor's ("boss") perception differed from the rest (a K-W comparing self+peers+boss yielded statistical significant differences with $\chi^2 = 8.54$, $p = 0.036$, $n = 87$). Beyond statistical inferences, later interviews with the managers involved in the project had a satisfactory opinion; remarking a more harmonious understanding among themselves, which impacted positively not only on safety performance results, but also on routine as well as unusual production problems.

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