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Linking empowering leadership to safety participation in nuclear power plants: A structural equation model☆

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ABSTRACT

Introduction: Safety participation is of paramount importance in guaranteeing the safe running of nuclear power plants. *Method:* The present study examined the effects of empowering leadership on safety participation. *Results:* Based on a sample of 495 employees from two Spanish nuclear power plants, structural equation modeling showed that empowering leadership has a significant relationship with safety participation, which is mediated by collaborative team learning. In addition, the results revealed that the relationship between empowering leadership and collaborative learning is partially mediated by the promotion of dialogue and open communication. *Conclusions:* The implications of these findings for safety research and their practical applications are outlined. *Impact on Industry:* An empowering leadership style enhances workers' safety performance, particularly safety participation behaviors. Safety participation is recommended to detect possible rule inconsistencies or misunderstood procedures and make workers aware of critical safety information and issues.

1. Introduction

Motivating organizational members to participate in safety systems and initiatives is a major concern in High Reliability Organizations (HROs). Although these complex technological systems are highly standardized in terms of safety rules and procedures, safety participation is of prime importance, since it makes it possible to identify and detect dysfunctionalities in system behavior that are not anticipated by the system design. Thus, compliance with safety rules and procedures provides reliability, whereas safety participation improves the capacity for safe conduct under less predictable circumstances (Zohar, 2008).

The academic literature provides few answers about how to strengthen employees' safety participation in high reliability environments, roughly linking the impact of leadership and safety climate on safety participation (e.g., Simard & Marchand, 1995). The present study explores how managers can specifically influence participative safety behavior in nuclear power plants. The assumption is that empowering leadership will improve safety participation, but its impact will be mediated by collaborative team learning. In order to strengthen collaborative learning, empowering leaders should also promote dialogue and open communication. In the following sections we introduce our research constructs and develop our hypotheses.

1.1. Safety participation

In keeping with traditional theories of job performance (e.g., Borman & Motowidlo, 1993; Katz & Kahn, 1966), Neal, Griffin, and Hart (2000) differentiate between two types of safety performance behaviors. *Safety compliance* refers to work activities that individuals need to perform in order to establish workplace safety. These behaviors include adhering to standard work procedures and wearing personal protective equipment. *Safety participation* describes behavior that does not directly contribute to an individual`s personal safety, but that helps to develop a safe work environment. It includes activities such as participating in voluntary safety tasks, helping coworkers with safety-related issues, or attending safety meetings. Whereas safety compliance describes work activities that contribute to an organization's primary task and are prescribed by formal job descriptions, safety participation describes voluntary activities that contribute to strengthening safety in the organization. These activities are also associated with broader participative concepts such as safety citizenship

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behavior (Hofmann, Morgeson, & Gerras, 2003), proactive safety (Parker, Turner, & Griffin, 2003), or commitment-based safety (LePine, Erez, & Johnson, 2002).

Empirical safety research has identified several factors as principal antecedents of safety participation. In manufacturing and mining organizations, Griffin and Neal (2000) found that motivation to participate in safety activities and knowledge about safety are significant predictors of safety participation. In a hospital, Neal et al. (2000) determined that safety knowledge, safety motivation, and safety climate are direct antecedents of safety participation. More recently, in a meta-analysis of studies from different industrial fields (most of them in the manufacturing industry), Clarke (2006) showed that safety climate is associated with safety participation to an even greater extent than safety compliance. In addition, in a recent meta-analysis, Christian, Bradley, Wallace, and Burke (2009) found safety knowledge to be a relevant antecedent of safety participation.

Leadership has also been identified as an important factor that influences safety participation. Based on Leader-Member Exchange theory (LMX), Hofmann et al. (2003) carried out a study with a U.S. army sample. They found that when managers and supervisors show safety commitment and concern for their employees' well-being, employees reciprocate by broadening their role definitions and showing safety-related organizational citizenship behaviors. In the manufacturing industry, Clarke and Ward (2006) found that some influence tactics performed by leaders (i.e., coalition building, rational persuasion, inspirational appeals, and consultation) had a significant direct relationship with safety participation, some of them (rational persuasion, inspirational appeals, and consultation) through the influence of safety climate.

The purpose of this study is to extend this line of research by analyzing the role of empowering leadership (Arnold, Arad, Rhoades, & Drasgow, 2000) in safety participation and identifying the potential mechanisms and processes that may lead to improving safety participation behavior. In contrast to existing studies on safety participation, which have predominantly been conducted in industrial domains where personal safety is at stake, our study is located in a work setting (nuclear power plants) where safety participation behaviors have hardly been studied. In these kinds of organizations, safety participation is embedded in a systemic organizational approach (i.e., safety management system) that mainly aims to optimize process safety. Due to the complex nature of safety in these systems, identifying, being aware of, and reporting dysfunctionalities in plant behavior are extremely important practices. Moreover, safety participation challenges the safety routinization that results from high levels of standardization in terms of rules and procedures, but produces the risk of not paying enough attention to critical and unanticipated safety issues (Frischknecht, 2005).

1.2. Empowering leadership

Within the nuclear field, research about leadership and its relationship to safety performance is rare. Kivimaki, Kalimo, and Salminen (1995) found that participative management (communicating and giving feedback to subordinates) was positively associated with safety performance. According to Flin and Yule (2004), some leadership techniques, such as stimulating certain styles, considering them individually and rewarding them, were found to foster leaders` impact on workers' safety behaviors. In a nuclear power plant, Martínez-Córcoles, Gracia, Tomás, and Peiró (2011) conducted a study that assessed the impact of an empowering leadership (EL) style on the perceived safety behavior of employees. Focusing on individual leadership, they found that leaders' empowering behaviors (i.e., leading by example, participative decision making, interacting with employees, etc.) enhanced perceived safety behaviors through their influence on safety climate. Moreover, these authors showed that empowering leaders positively influence employees' safety climate in both strong and weak safety cultures. However, the effect of this relationship was different depending on the strength of the safety culture. Surprisingly, a positive relationship was greater in weak safety culture conditions. However, better safety results were obtained when empowering leadership was embedded in a strong safety culture.

In line with the aforementioned study, we want to examine the impact of an empowering leadership (EL) style on safety participation. The empowering leadership model developed by Arnold et al. (2000) claims that the main function of a leader is to increase the team's potential for self-management. They distinguish five dimensions corresponding to different behaviors that empowering leaders should show. "Leading by example" refers to a set of behaviors that demonstrate the leader's commitment to his or her own work and to the work of his or her team members. The leader serves as a role model and stands up for what he/she thinks is the right way to perform the job. "Participative decision making" refers to the leader's use of members' inputs in decision-making. The leader`s behavioral repertoire may range from delegating decisions to his team members to encouraging them to express their ideas and opinions. Tjosvold (1990) found that members of a flight crew performed more effectively in risky situations when team members were motivated by their leaders to contribute to team performance with their ideas. "Coaching," another relevant dimension, involves the ability of leaders to encourage their team members to solve problems in a self-managed way, thereby providing members with opportunities to share and increase their knowledge. Yule, Flin, and Murdy (2007) found that as team knowledge increases, the propensity to engage in risk-taking behaviors decreases. The fourth dimension is "informing," which refers to the dissemination of information by leaders about the organization's mission, philosophy, or other important information. Finally, "showing concern/interacting with employees" focuses on behaviors such as taking time to discuss members' concerns or showing concern for their welfare. Katsva and Condrey (2005) highlight individual treatment and feedback as crucial in obtaining good safety outcomes in nuclear power plants. Although the EL style (by Arnold et al., 2000) was originally composed of five different dimensions, other dimensional structures have been studied due to the high correlations detected by these authors among the five dimensions. For instance, a one-dimensional model that encompasses the five dimensions was recently chosen as the best dimensional model, using an adapted scale within the nuclear field (Martínez-Córcoles et al., 2011).

The EL model embraces leadership behaviors that might be especially relevant for nuclear power plants. It not only encompasses task-focused behaviors such as facilitating the understanding of task requirements and motivating task compliance Burke et al. (2006); it also integrates person-focused behavior (e.g., showing concern/interacting with employees) that facilitates behavioral interactions and, therefore, should motivate team members to contribute to (informal) safety discussions and (formal) safety systems. Although enforcing compliance with rules and procedures is an important function of leaders in establishing safety system in nuclear power plants, person-focused leadership behavior has the potential to enhance employees' safety performance by going beyond mere compliance with safety standards (e.g., by reporting near-misses or minor events). Since nuclear power plants are highly standardized work settings, safety participation helps to shed light on inconsistent rules and procedures or deviations from specified technical operations.

In order to better understand the leadership-safety participation link, we assume that several factors have to be in place and developed. In the following sections, the paths through which EL may positively influence employees' safety participation are considered, and corresponding hypotheses are stated. We assume that safety participation is strongly embedded in a team learning context where team members collaboratively learn from each other. Thus, enhancing team learning is a privileged way for leaders to promote participative safety behaviors.

1.3. Leadership, collaborative learning and safety participation

As stated above, the EL model aims to increase teams' self-management skills. Empowering leaders foster group processes that facilitate the exchange of information among team members and the development of team knowledge. According to Srivastava, Bartol, and Locke (2006), empowering leaders have the potential to enhance knowledge sharing in groups by giving team members autonomy. Whereas autocratic leadership mainly initiates instructed learning[1] processes (with less autonomy) in teams (Yukl, 2002), empowering leadership provides conditions that allow for collaborative learning processes among team members. According to Tomasello, Kruger, and Ratner (1993), collaborative learning involves the transmission and co-construction of knowledge.[2] It takes place when symmetrical (i.e., neither team member is seen as the only authority) and reciprocity-based interactions are established. Moreover, team members have to accept responsibility for group actions, such as the management of work methods, peer process monitoring, and the assignment of group members to work tasks (Panitz, 1997). The most important outcome of collaborative team learning is the development of shared or co-constructed knowledge.

With regard to safety research, Griffin and Neal (2000) showed that safety knowledge is a mediator between safety climate and safety performance. In their study, safety knowledge predicts safety compliance and safety participation, with a stronger empirical relationship between safety knowledge and safety participation. Similarly, the recent meta-analysis by Christian et al. (2009) on the antecedents of safety performance highlights safety knowledge as a potential direct antecedent of safety compliance ($M\rho = .60$) and safety participation ($M\rho = .61$). Both studies lead to the conclusion that teams' collaboratively-developed safety knowledge (neither study specifies the context in which safety knowledge is developed) is an antecedent of safety participation.

Therefore, empowering leadership should be positively associated with safety participation behaviors through collaborative learning interactions among the team members:

Hypothesis 1. Collaborative learning will mediate the relation between empowering leadership and employees' safety participation.

1.4. Leadership, dialogue and open communication, and collaborative learning

The EL model provides a broad range of behavioral actions that have the potential to promote collaborative team learning. For instance, empowering leaders coach team members to solve problems in a self-managed way, or they show commitment to their work. Therefore, our first hypothesis states that empowering leadership has a direct influence on collaborative team learning. However, we assume that empowering leadership also exhibits an indirect influence on collaborative learning. Some dimensions of the EL model, such as encouraging team members to contribute their opinions or displaying a participative decision-making style, clearly involve communication between the leader and team members. In order to facilitate collaborative team learning about safety, empowering leaders must communicate openly and honestly about safety topics and motivate their team members to do the same. The promotion of dialogue and open communication is extremely relevant in safety performance settings in terms of: (a) reporting problems or deficiencies in one's own performance or other team members' performance; (b) recognizing one's own lack of knowledge about different topics or about how some tasks must be done; (c) favoring the exchange of different opinions and points of view that can lead to better team coordination; and (d) avoiding group thinking (Bresó, Gracia, Latorre, & Peiró, 2008). From this perspective, empowering leaders indirectly contribute to creating a collaborative learning environment within a team through the promotion of dialogue and open communication. For this reason, our second hypothesis reads as follows:

Hypothesis 2. Dialogue promotion and open communication will partially mediate the relation between leadership and collaborative learning.

2. Method

2.1. Participants and Procedure

Our sample was composed of 495 workers from two nuclear power plants. The total size for both organizations was 760 employees. Data were collected in March 2011. A response rate of 65.1% was obtained. All responsibility levels and functional areas in the nuclear facility were included. Responsibility levels included the nuclear plants general manager, department managers (operation, maintenance, technical support, and radiological and environmental protection), supervisors from each unit within departments (e.g., maintenance department is composed by mechanic maintenance unit, electric maintenance unit), and the staff working in these units. All employees worked in 3 different shifts of 8 hours each one.

Within our sample, 3% of the respondents are younger than 30 years old, 18% are between 30 and 45 years of age, and 79% are older than 45 years of age. In addition, 47.3% of the respondents hold a university degree.

The questionnaire was administered in the workplace as part of a set of questionnaires designed to evaluate safety culture. Several researchers went to the workplace and stayed there for about three days to collect data in each facility. Participation was voluntary and took place during work time. Anonymity and confidentiality were guaranteed. Data were collected in sessions where a group of participants individually filled out the questionnaires. The time required to fill out the questionnaires was about 30 minutes. In all sessions, the researchers explained the objective of the research and were available to answer employees' questions.

2.2. Measures

2.2.1. Empowering leadership

An adaptation of the "Empowering Leadership Questionnaire (ELQ)" (Arnold et al., 2000) was used as unidimensional, since a one-dimensional model was recently chosen as the best factor solution regarding previous safety research within the nuclear field (see Martínez-Córcoles et al., 2011) with the same scale. The scale contained a total of 17 items, after omitting some items from the original scale due to time constraints (the original scale contains 38 Items). A 5-point Likert response scale ranging from 1 (*never*) to 5 (*always*) was used. Items covered the five dimensions of the theoretical construct proposed by Arnold et al. (2000). Three items corresponded to "leading by example," three items to "participative decision making," four items to "coaching," four items to "informing," and three items to "showing concern/ interacting with employees." Sample items assessing empowering leadership include: my immediate boss "sets high standards for safety performance through his/her own behavior," "encourages work group members to express ideas/ suggestions," or "pays attention to my work group's efforts." Internal consistency reliability for the scale was .98.

[1] Instructed learning refers to the learning process in which learners internalize the instructions of the teacher and subsequently use them to self-regulate their own attentional or other cognitive functions (Tomasello et al., 1993).

[2] Co-construction of knowledge refers to the process in which an individual adds knowledge to the knowledge which has been previously developed by others.

2.2.2. Dialogue promotion and open communication

We used the following 5 items with a 5- point Likert response scale ranging from 1 (Never or almost never) to 5 (Always or almost always): "Different points of view are expressed openly and sincerely;" "People are encouraged to ask "why," regardless of their rank;" "The points of view of others are listened to;" "Two-way communication (boss-subordinate and subordinate-boss) is frequently used;" and "We question each other when we think the work can be done better." Items were extracted from the original scale by Bresó et al. (2008). Internal consistency reliability for the present scale was .87.

2.2.3. Collaborative team learning

To measure collaborative team learning, the following 4 items were used: "We learn from each other;" "Knowledge is shared among the different team members;" "Teamwork is encouraged as a way of learning from others;" and "In group discussions, everyone's opinion is taken into consideration." With a 5- point Likert response scale ranging from 1 (Never or almost never) to 5 (Always or almost always), these items were extracted from the original scale by Bresó et al. (2008). Internal consistency reliability for this scale was .83.

2.2.4. Safety participation

We used the original safety participation scale by Griffin and Neal (2000). The scale consisted of three items, with a 5-point Likert response scale ranging from 1 (*Completely disagree*) to 5 (*Completely agree*). Scale items were: "I promote the safety program within the organization;" "I make extra effort to improve safety in the workplace;" and "I voluntarily carry out tasks or activities that help to improve workplace safety." Internal consistency reliability for the safety participation scale was .86.

2.3. Analyses

The first step in the data analysis was to test the factorial structure of the scales used in our sample in order to obtain evidence of their validity. For this purpose, we performed confirmatory factor analyses (CFA) using LISREL 8.8 (Jöreskog & Sörbom, 2006). Robust Maximum Likelihood (ML) was used to estimate model parameters (as the large number of items involved and the sample size impeded the use of weighted least square estimation), and both the polychoric correlations matrix and the asymptotic covariances matrix were used as input for the analyses, considering the ordinal nature of the variables.

The scales were included in the same battery of questionnaires (participants responded to the scales sequentially and in an immediate way), and the method used was the same for all of the respondents. Therefore, we first conducted a confirmatory factor analysis using the four scales together. The Empowering Leadership scale [adapted from Arnold et al. (2000)] was introduced as one-dimensional, as mentioned above. The other three variables measured (dialogue promotion and open communication, collaborative team learning, and safety participation) were also introduced as one-dimensional scales. Second, we examined the possibility that a single factor could emerge for these four constructs, confirming that common variance might inflate the association among the study variables (all of them were obtained by means of self-report). Thus, a Harman Single Factor test was carried out using the Confirmatory Factor Analysis Method (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). Its basic assumption is that if a substantial amount of common method variance is present, either a single factor will emerge from the factor analysis or one general factor will account for the majority of covariance among the measures, with all items loading in this single factor. To explore this question, we conducted a second confirmatory factor analysis in which all the items from the four variables loaded in a single factor.

In order to assess the fit of the models, we examined the RMSEA (root mean square error of approximation), CFI (comparative fit index), and NNFI (non-normed fit index). The interpretation of these indexes is as follows: RMSEA $<.08$ = acceptable model (Browne & Cudeck, 1993; Browne & Du Toit, 1992); CFI $>.90$ = acceptable model, and $>.95$ = excellent model (Marsh, Hau, & Grayson, 2005); NNFI $>.90$ = acceptable model, and $>.95$ = excellent model (Marsh et al.). In order to test differences between models and decide which one presents a better fit, a modeling rationale was considered. Some criteria have been proposed in the literature to interpret differences in practical fit indices based on modeling rationale criteria. Thus, for example, differences not larger than 0.01 between NNFI and CFI values (ΔNNFI and ΔCFI) are considered an indication of negligible practical differences (Cheung & Rensvold, 2002; Widaman, 1985). Chen (2007) suggests that when the RMSEA increases by less than .015, one can also claim support for the more constrained (parsimonious) model.

Finally, with the purpose of providing support for our hypotheses, we executed a structural equation model (SEM) with observed variables by using LISREL 8.8. As we were introducing continuous variables, we used maximum likelihood methods (ML) to estimate the model parameters. All the variables assumed a normal distribution; thus, we used a Pearson correlation matrix as input for the analysis. We also employed the RMSEA, CFI, and NNFI indexes to determine the fit for the model. The interpretation of the goodness of fit indexes was the same as in the confirmatory factor analysis.

3. Results

Descriptive statistics and alpha coefficients (Cronbach, 1951) for all measures are presented in Table 1. In general, the participants reported high scores for leadership ($M = 3.52$, $SD = .97$), dialogue promotion and open communication ($M = 3.57$, $SD = .80$), collaborative learning ($M = 3.72$, $SD = .83$), and safety participation ($M = 4.10$, $SD = .75$). Pearson correlations revealed positive relations among all the variables ($p < .01$) (see Table 1).

3.1. Confirmatory factor analyses

Two Confirmatory Factor Analyses (CFA) were performed: A four-factor model (one for each scale) and a single-factor model (associated with all the items on the four scales). The four-factor model provided an excellent fit ($\chi^2 = 1335.671$, df = 371, p < .01; RMSEA = .076; CFI = .985; NNFI = .984), and all the estimated parameters were statistically significant (p < .05). Results indicated that each item saturated in its corresponding scale. However, the single-factor model did not show such a good fit ($\chi^2 = 3773.049$, df = 377, p < .01; RMSEA = .141; CFI = .949; NNFI = .945). Results showed that a single-factor model did not explain our data as well as the predicted model (four factors), in which our variables were considered different constructs. All the goodness of fit indexes are satisfactory for the four-factor model, whereas the single factor model shows a poor fit to data (cut-off values in RMSEA are not reached). Moreover, the incremental fit indices indicated significant differences between the two tested models on the NNFI and CFI indexes. In sum, the four-factor model was chosen as the best model.

Table 1
Descriptive statistics, Cronbach's alpha, and intercorrelations between study variables.

Factor	M	SD	Cronbach's α	1	2	3	4
1. Leadership	3.52	.97	.98	-			
2. Dialogue promotion & open communication	3.57	.80	.87	.64**	-		
3. Collaborative learning	3.72	.83	.83	.64**	.79**	-	
4. Safety participation	4.10	.75	.86	.37**	.39**	.36**	-

** p<.01.

3.2. Structural equation model

The structural equation analysis performed to test the proposed hypotheses revealed an excellent fit ($\chi^2 = 4.542$, df = 2, $p < .01$; RMSEA = .053; CFI = .996; NNFI = .989). All the estimated parameters were statistically significant ($p < .01$) and showed the expected sign, supporting our hypotheses. Paths between variables and standardized parameters are presented in Fig. 1.

Results indicated that the two tested hypotheses were clearly confirmed. Collaborative learning turned out to be a mediator in the relationship between leadership and employees' safety participation (Hypothesis 1), and dialogue promotion and open communication partially mediated the influence of leadership on collaborative learning (Hypothesis 2). In other words, collaborative learning is the path through which empowering leaders heighten employees' safety participation behaviors. At the same time, the impact of leadership on collaborative learning is enhanced by an atmosphere of open communication promoted by empowering leaders.

4. Discussion

The main goal of the present paper was to identify the ways managers influence safety participation in nuclear power plants, paying special attention to the role of collaborative learning. Little research exists about how employees' safety participation is promoted by leadership in HROs, particularly in the nuclear industry. The results provided in the present article have two important implications for safety research.

First, we extend the findings of Martínez-Córcoles et al. (2011), who assessed the impact of EL on safety performance in general by showing that empowering leadership has the potential to specifically enhance safety participation. When employees demonstrate initiative and promote safety programs within their organization, they become aware of safety concerns, confront their co-workers with different meanings for safety, and potentially revise their assumptions about safety. Thus, empowering leadership qualifies employees to develop and perceive multiple perspectives of safety issues. The probability of detecting danger signals increases as organizational members participate more. This aspect is especially important in nuclear power plants, where unexpected dysfunctionalities have to be detected as soon as possible due to their high hazard potential. Within this performance context, safety participation strongly contributes to process safety and goes beyond the popular safety performance goal of "compliance with rules and procedures."

Second, empowering leadership induces a collaborative learning environment, which makes employees behave in a proactive and participative way with regard to safety. This result is consistent with findings from previous studies on empowering leadership (e.g., Hechanova-Alampay & Beehr, 2001), and it highlights the importance of giving autonomy to team members. It reveals that an empowering leadership style is able to trigger a collaborative learning process, beyond the instructed learning process where the leader does not share power or offer autonomy to his/her employees. One key way to foster collaborative learning seems to be the promotion of open and honest communication, which agrees with the claim that safety concerns have to be observed in what leaders say and do (Hofmann, Jacobs, & Landy, 1995). Especially in safety performance settings, safety is quite often taken for granted. Organizational members do not talk explicitly about safety, since it is considered part of normal or routine operations. Therefore, promoting dialogue and open communication seems to be important in fostering discussions about safety and co-constructing safety knowledge through collaboration. This argument follows the requirements for a sound safety culture in nuclear power plants as defined by the International Atomic Energy Agency, which promotes the concepts of a questioning attitude and open communication (INSAG-4, 1991).

There are several limitations to this study. First of all, we used self-reported measures of safety performance, which means our results may have been inflated due to respondents' tendency to respond in a consistent manner or answer in a socially desirable way. However, we guaranteed the anonymous and confidential nature of the survey in order to obtain reliable data. Future studies could benefit from using objective measures of safety performance in order to validate the impact of empowering leadership on safety participation. Second, our study has a cross-sectional nature, reducing our variables to a "snapshot" rather than assessing them over time. Longitudinal assessment, especially for dynamic constructs like safety participation and collaborative learning, would provide further validation of the specific relationships. Third, we have tested leader behaviors at all hierarchical levels within the same study. Thus, we were able to determine which behaviors a direct leader must exhibit to promote collaborative learning in his/her employees, but we were not able to say which behaviors are more appropriate at different levels of the hierarchical structure. Future research could explore whether appropriate leadership behaviors differ according to the level, supervisor, middle-management, or senior management (Flin & Yule, 2004). Finally, we only consider the effects of empowering leadership at the individual level, ignoring organizational factors and the existence of work units that group organizational members. However, these multilevel phenomena might also contribute to collaborative learning environments and, in turn, strengthen safety participation. Therefore, future studies should approach these issues from a multilevel perspective.

Despite these limitations, the results reveal that empowering leadership can have a significant effect on employees' safety participation. This relationship is reflected in the promotion of dialogue and open communication as well as in collaborative learning processes. We believe that the empowering leadership model is suitable for a highly standardized work setting like a nuclear power plant. Safety participation should complement safety compliance, since procedures cannot cover all possible risks, even in highly standardized operations and equally routinized work (Zohar, 2008). Safety participation is a key behavior in keeping workers aware of safety-critical information and issues, and empowering leaders can motivate their

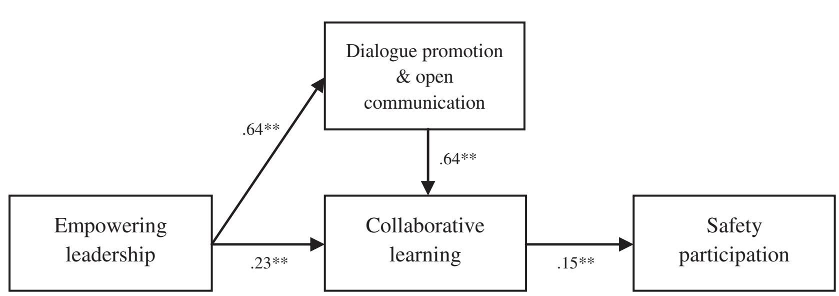

Fig. 1. Paths between variables and standardized parameters. **$p < .01$.

employees to behave in a voluntary and proactive way by promoting open communication and collaborative learning.

5. Conclusion

In light of our empirical findings, we can conclude that empowering leadership is an important lever to promote safety participation when leaders succeed in strengthening collaborative team learning. In other words, when leaders show empowering behaviors, they facilitate collaborative learning processes that result in increased safety participation (Hypothesis 1). We also tested the way empowering leaders might indirectly contribute to creating a collaborative learning environment. We obtained support for our second hypothesis, which stated that open and honest communication partially mediates the relationship between empowering leadership and collaborative learning (Hypothesis 2). Thus, empowering leaders promote collaborative learning not only directly, but also by encouraging dialogue and open communication in their teams.

5.1. Impact on nuclear industry

Nuclear power plants are hazardous environments where irregularities can have devastating effects. Besides establishing safety through technical systems and barriers, a lot of interventions and approaches have been developed to optimize the human factor in these systems. One important factor is leadership, which is generally assumed to have the potential to influence the safety performance of organizational members. Although this implication is stressed in a lot of nuclear industry publications (e.g. INSAG-15, 2002; INSAG-4, 1991; International Atomic Energy Agency, 2007, 2008), the ways managers should behave in order to optimize the safety performance of their subordinates are relatively vague. The present study examined an empowering leadership style and its impact on safety participation. It becomes evident that: (a) empowering leadership promotes collaborative learning, which in turn enhances safety participation; and (b) the promotion of dialogue and open communication is another important way to strengthen collaborative learning. Therefore, safety participation is an important way to tackle unexpected system behavior, which has the potential to strengthen an organization`s resilience. Moreover, safety participation complements the popular rule compliance approach, as it can help to detect possible rule inconsistencies or misunderstood procedures and make workers aware of critical safety information and issues. In addition to safety systems and initiatives in nuclear power plants, an important pre-condition is for organizational members to collaborate on safety issues and develop and co-construct their safety knowledge, thus enhancing their motivation to participate. And leaders can have a positive impact on this process.

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