

Implementation of HSE culture using CRM techniques in the construction industry

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Short Report

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Abstract

The project's objective is to make HSE more accessible and tangible in acquiring competencies and transferring HSE training content to practice by showing its relevance concerning a novel operation protocol. Although individually CRM has a high potential to improve the safety, health, and environmental (HSE) culture of individuals and reduce errors in various areas, its implementation in the construction industry and an integrated manner has not been investigated. The authors investigated the effect of the implementation of HSE-CRM in a project for a housing complex in Karaj, with 230 staff. Despite the assessment that said this training is slightly more difficult, staff reacted more positively to this training than to standard training. Across all responses, there was statistically considerable growth in scores on the HSE culture survey items. Also, this process improved teamwork, performance, efficiency, and staff morale. Most participants said this training format was seen as livelier, more interesting, and more practically relevant. After one year, participants claimed this approach protected the HSE Chief and other managers from distractions and wasted time at the beginning of each shift. The result of the project shows that this technique can be used in the environment of construction.

1. Introduction

Crew Resource Management (CRM) was implemented more than three decades ago to optimize flight deck management and safety and improve flight crew team performance in the aviation training curriculum [1]. First, in 1977, the term was used by an American aviation psychologist. He aimed to use all available resources (people, equipment, information, and so on) to get safe and efficient flights [2]. One of the reasons for its use was that statistics on airplane accidents from the National Transportation Safety Board showed that 73 percent of fatalities were caused by flight crew malfunctions rather than technical problems[3]. In addition, NASA's extensive research in the 1970s showed that in order to reduce accidents, there is a need to focus on non-technical training such as leadership, command, decision-making, communication, and teamwork of pilots[4].

The aviation industry now applied CRM and conducted three-day training courses for their staff, followed by monitoring their CRM skills during simulator flights [4, 5]. Essentially, CRM involves enhancing team members' understanding of human performance, particularly the social and cognitive aspects of effective teamwork and good decision-making[2, 5]. Since the mid-1990s, other industries have also shown significant interest in adapting and implementing CRM training to train their employees in non-technical skills[2]. For example, the use of aviation CRM techniques is well documented in the healthcare literature and has led to positive outcomes in healthcare[5].

HSE culture enables vigilance, blame reduction, prioritized learning, standardization of routine procedures, and institutionalized behaviors to effectively manage unpredictable emergencies [5].

HSE culture is defined as the product of group values, attitudes, and behavioral patterns that affect the safety and health activities of the organization[6]. Efforts to improve HSE culture are generally well-received, as perceptions of strong HSE cultures appear to be associated with fewer adverse events or

other indicators of potential harm[7]. Various strategies can be used to improve safety culture, including CRM, which is a systematic approach to training teams in interpersonal communication, leadership, and decision-making practices[8, 9]. This tool allows teams to function effectively even under difficult and unpredictable conditions[9].

Despite the high potential that this tool has shown in various industries such as aviation[10], medicine[11], oil[9, 12], automotive[13], and maritime industry[1], however, the potential of CRM to create similar results in the construction industry and create inherent cultures in it has not been well proven. As a result, building a strong HSE culture has been a fundamental goal of many systems to improve HSE implementation especially since the International Labour Organization reported on the staggering number of accidents, errors, adverse events, and near misses that occur in construction each year[14]

According to the statistics announced by Iran's ministry of cooperative labour social welfare 2020, 45% of all accidents during work in the country are related to construction activities. Three thousand 616 accidents occurred among construction workers in 2019 and on average 800 to 1000 construction workers die annually due to a lack of work safety[15]. This report shows that companies should pay more attention to safety issues in this industry in order to reduce these incidents.

The gradual removal of civil engineers from the construction industry in Iran, the decreased knowledge and skills among civil engineers, technicians, and managers, the lack of awareness and knowledge of them about the necessity of compliance with safety issues, and the lack of experts due to the migration, the low IQ of existing employees[16, 17], and other issues would create uncertain problems, especially about safety issues. These issues could lead to increased costs, delays, and countless problems in the Health, Safety, and Environment (HSE) sector. One of the problems would be the loss of HSE culture and its inherent culture. In a society that is devoid of experts, second and third-level people gain power. The knowledge illusion is high in these people. Now that they have gained power, they assume it is the result of their efforts. They consider themselves knowledgeable about science and laws. These people accept anything to gain power and money and think less about the consequences of tasks. Therefore, it is very difficult to inform these people and train them. As the famous saying goes: "When the cat's away, the mice will play".

TAHSEEN company faced 9 obstacles in creating an HSE culture. In another article, these 9 obstacles and their prioritization have been discussed. In this prioritization, they realized that the educational and personal-cognitive barrier is one of the barriers to high priority. These obstacles are strongly related to other obstacles and factors; such as learning, applying, interest in learning and applying, becoming institutionalized, awareness of risks, commitment, and responsibility. On the other hand, the political and economic barriers are also very strong. Therefore, now it seems necessary to use new methods. Now the question is how to teach safety in a fun way to its learning speed is high, and education is institutionalized in people, little by little it becomes a culture, ability to improve and develop. For this reason, different methods were investigated. Due to the new public reporting and feedback paradigms including the performance of HSE indicators, safety care in the construction industry is far beyond other

industries. However, the effectiveness of this technique has been significant in terms of training and safety in other industries. Thus, it is essential to determine the effectiveness of CRM in improving the HSE culture in the construction industry. In order to address this vital opportunity for cultural transformation and improve HSE performance, this study investigated the impact of systematically implementing CRM in a construction project on employees' perceptions of the performance of safety, health, and environment (HSE) and HSE culture. This training program aims to apply the CRM approach to improve teamwork and team communication, improve training performance, improve decision-making, encourage team members to accept personal responsibility to ensure employees' safety and health and create a special HSE culture.

2. Methods

2.1. Settings

The statistical population of the project includes a residential complex in Karaj, with 203 workers, 15 technicians, 7 managers, and 5 HSE unit personnel (Table1). Most of the employees of this organization participated in a 3-hour safety, health, and health course a year ago. First, HSE practitioners classified the statistical population according to their level of familiarity with safety issues by conducting an interview. All roles are listed in Table1.

Table 1

Organizational classification and operational categories

Training and operational categories			Organizational classification		
Categories	Description of the category	NO	Personnel		NO
A	The staff has undergone HSE professional courses, advanced first aid, and in addition, have a university education.	0	Managers	Project manager	1
				Administration/ Site Manager	1
				Unit Manager	5
B	Staff have attended HSE professional courses and have university education in addition.	2	HSE unit personnel	HSE Chief	1
C	Staff have taken HSE courses and have at least an associate's degree.	3		HSE Experts	4
D[1]*	Staff who have passed HSE foundation courses.	15	Technician		15
E	Staff who have passed the first aid course.	9	Worker		203
F	Staff who are familiar with first aid but do not have a degree.	36			
G	The staff has no training and familiarity with first aid and HSE principles.	165			

This category is adapted from other industries such as nursing[18, 19], medicine[20, 21], and oil[22]. This new category was created for training and implementation of the CRM protocol in the project. These categories were introduced to them as new categorizations of employees shortly before the CRM training session. This new category was created to train and implement the project's CRM protocol. All people who work in the organization are identified as Staff. These staff could include the chairman of the board, CEO, project manager, executive director, technicians, experts, workers, and HSE personnel. Now they were categorized based on their level of familiarity with HSE. The categorization order is based on responsibility, decision-making, and executive power in the field of HSE. According to these categorizations, an HSE operational protocol has been defined to carry out HSE operations under normal and critical conditions. This categorization is for the creation of the "sterile cockpit rule" (SCR). SCR was created to prohibit crew members from fulfilling non-essential activities/duties. Its goal is all about keeping the air crew's environment free of distractions that might compromise safety while the aircraft is involved in flight operations conducted below 10,000 feet mean sea level [23-25]. With the help of this method, the knowledge level of employees is determined, it becomes easy to equal knowledge according to levels and positions of staff, and effective protocol implementation and better feedback, and makes an opportunity for effective protocol implementation and better feedback.

This set provides a unique environment for the implementation of CRM where there is potential for employees - who are required to attend CRM training - to transfer this knowledge and experience to other company projects.

2.2. Training

Training included CRM and HSE training. CRM training is one method of training methods [26]. This method is designed to improve and upgrade individual and team performance. Therefore, experts use methods to strengthen knowledge, well-tested training tools, attitudes involved in behavioral categories, and skills, such as situational awareness, self-expression, or Error Types Adams and Hester [2]. HSE training included actions and exercises in normal and emergency procedures and related regulations. For example, the safety duties of each employee according to the defined category, evacuation methods, waste reduction, etc[6, 27]. Therefore, Frequent employee training included theoretical and practical training on HSE as well as CRM issues along with individual training. Since technical and non-technical skills cannot be separated, and both are critical and overlapping areas for achieving safe and efficient operations, CRM is an integral part of safety training.

An integrative approach, which creates a more authentic and functional learning environment, is also justified by the situated cognition movement in instructional design, which states that all learning is situated and occurs within a larger context of social interactions and constructed meanings[3]. Although the integrated training was assessed as being slightly tougher and not much oriented toward instructional design principles, the researchers claim participants reacted more positively to the integrated training and fun creative education than individual classic HSE or CRM training. Because it was seen as livelier, more fun, more interesting, more practical, and also more relevant.[28, 29].

For this reason, integrated problem-based training was defined. That is, in addition to teaching theory, training was designed based on events, situations, or phenomena that are valid and relevant to learners. In other words, incidents or phenomena were discussed and practiced from the perspective of HSE as well as from the perspective of CRM. In this way, by intertwining CRM with HSE training and creating an integrated training environment, it becomes more similar to the "close to work" environment. The design or duration of recurrent training for employees is left to the discretion of the operator and the national regulator, which must approve the training program. The training was one day a week, at the end of the work week for 3 hours. The training consisted of two 3-hour modular training sessions and then a 2-hour operational simulation session. The implementation of the HSE Crew Resource Management (HSE-CRM) project began in the summer of 2020, one month after the on-site training session. This tutorial included creating teamwork, communication through leadership, management of conflicts and contradictions, mutual reviews, standard protocols, communication scripts, ensuring critical communication through assertive advocacy, and strategies to support situational awareness and decision-making such as the use of briefings and checklists and managing distractions, movie show, simulation of events with the cooperation of employees and the implementation of protocols was according to the type of operation defined for different levels of staff (which was stated in Table 1).

More information on the implementation process, timeline, etc. can be found in subsequent articles on CRM implementation. After the training, some units localized and tailored a specific HSE-CRM, and used some learned tools according to the operational characteristics of their unit. The HSE-CRM support unit had monthly follow-ups with each unit to provide ongoing support throughout their HSE-CRM project and coach HSE teams on the ongoing use of CRM tools.

2.3. Survey tool

The survey tool consists of 40 items that address 14 dimensions of HSE culture (Table2):

Table 2

Dimensions of HSE culture

#	Dimensions	#	Dimensions
1	Teamwork Within Units	8	Frequency of Events Reported
2	The HSE department Promotes Staffs safety	9	Encourage reporting of any safety concerns
3	Organizational Learning—Continuous Improvement	10	Teamwork Across units
4	Management Support for Staff's safety	11	Job satisfaction of Staffing
5	Overall Perceptions of HSE	12	Increasing morale in the field of compliance with safety issues before and after work
6	Feedback & Communication About Errors	13	Collect information, Handoffs & Transitions, Transmission injured
7	Communication Openness	14	Nonpunitive Response to Errors

This tool has been widely used to measure cultural transformation, in the studied project, with medium to strong validity and reliability in different dimensions. Two open questions were also included at the end of the survey instrument: Please give us your recommendations for improving HSE on construction projects and please leave any comments regarding safety, error, or incident reporting on a project you are working on. Before the training, the familiarity of the staff was checked by sending a questionnaire electronically. After the training, the questionnaire was again sent to staff.

[1] * In Iran, qualified operating engineers building and workshop supervisors should see HSE introductory courses.

3. Results

One of the purposes of this project was to improve the knowledge of staff, use the ability of the staff who are familiar with first aid and HSE, and empower them. Until now, job responsibilities for staff

familiar with first aid and HSE were not well defined. All the staff had interfered with the HSE unit, especially from the HSE point of view, especially at the time of the accident by doing unrelated work that was not their responsibility. Previously, all supervision was performed by HSE unit personnel and workshop supervisors. But now, for example, an effort was made to match capability, especially between E, F, and G. Therefore, now with the aid of this course, there are two categories, E and F, in terms of having a degree/certificate (Table1). According to the SCR, these staff could check, identify and report HSE issues at the beginning of each shift and during daily work. Thus, the initial inspection is done by the F and E categories and they give the initial report. These categories include workers and technicians. Their efficiency has increased to take precautionary measures. In other words, with the aid of SCR, staff could collect symptoms of accidents or health and environmental issues and focus on their tasks. This also made people act according to the defined protocol when the accident occurred, not like before. They could perform minimum first aid measures in the event of an accident until HSE personnel arrive, then after the HSE unit comes entry, they could be as an auxiliary force, and if necessary, according to the order of the HSE unit, they could leave the scene without causing any disturbance. As a result, the new HSE hierarchy at the time of the accident was able to be highly efficient.

Now the HSE unit found an opportunity in order to apply CRM techniques to create a novel protocol and standardize the role of staff. After the CRM training, the project managers stated that the application of these techniques led to improved results in teamwork and HSE performance in their project and increased employee morale. After implementing HSE-CRM, the organization decided to implement an adaptation of SCR as its CRM project with the aim of improving the efficiency and accuracy of HSE assessments performed for other staff. This is due to measuring them. Managing directors, the organization's board of directors, and other managers who work far from the executive environment, who suppose they have the competence to make decisions on safety or HSE issues, have the lowest decision-making power, even though they may have been trained in HSE professional courses. This protocol is in order to isolate the environment and prevent interferences.

3.1. Response rate

The response rate (amount of responses/number of personnel) was calculated for each unit (Table3).

Table 3

The response rates

Staff	NO	Pre-CRM	Post-CRM
Workers	203	26%	88%
Technicians	15	53%	67%
Managers	7	71%	100%
HSE department/unit personnel	5	100%	100%

In addition to the questionnaire, in the first year after HSE-CRM training, HSE staff also followed up on the following performance criteria: Time required to complete initial staff and site assessments at the beginning of each shift (including site, site, and staff reviews – including covid-19 screening), Time required for HSE Chief to complete agendas and permit to work, Time required for HSE Experts to collect problem information, The time required for the HSE unit to provide assistance and notify the emergency, and the number of near misses and incident reports. Efficiencies in HSE unit functions depend on this information and are confirmed and vouched according to it. Table 4 compares performance before the course, two months after the course, and one year after the course.

Table 4

Average reported performance

HSE performance criteria		Pre-CRM	Pre-CRM	
			1	2
1	Time required to complete initial staff and site assessments at the beginning of each shift	there was no info	1:30'	00:30'
2	Time required for HSE Chief to complete agendas and permit to work	there was no info	2:30'	1:00'
3	Time required for HSE Experts to collect problem information	3:00'	2:00'	1:30'
4	The time required for the HSE unit to provide assistance and notify the emergency	0:20'	0:20'	0:10'
5	The number of reports of incidents and near misses	37	29	12

Items 1 and 2 were not checked before and are now considered. Within months of implementing CRM and SCR, the unit experienced vast efficiency improvements and was allowed more time for HSE interventions. To explain the reduction of the values table4, it is assumed that it is because, before each shift work, the site maps and the site itself are checked to check for high-risk factors. Before employees start work, the results of the assessments performed and critical information about critical items are available to them at the beginning of the shift. These improvements included rapid staff and site assessments, completion of permits to work, faster follow-up of problem information, and faster intervention when conditions worsened. A significant improvement was made in the efficiency of field checks at the beginning of each shift and incident prevention.

3.2. Improve staff understanding of teamwork, communication, and patient safety

Comparing the results of employees' responses before and after the HSE-CRM project shows that employees' perception of teamwork and HSE has improved (Figure 1-7). Using χ^2 analysis for multiple comparisons, responses pre- and post-CRM (one year later) were compared. All domains of the

questionnaire showed improvement between pre- and post-CRM. The data was analyzed using SPSS and Excel.

The remarkable thing is the significant improvement in the morale of the employees. The support unit confirmed this finding through staff reports and follow-up telephone interviews. One of the notable points was the sense of importance and pride in the workers and technicians (E & F) for their ability to provide timely and important information about possible risks at the beginning of the shift. On the other hand, HSE Experts were grateful for their consistent and effective input in the field investigation and compliance with HSE issues. In subsequent interviews with workers and technicians, several reported that this project allowed them to increase their judgment in their areas of responsibility in HSE. Because they could immediately transfer the relevant information to the project executive and the HSE department. This act created a feeling of empowerment for the workers and technicians and made them feel that they were an important and valuable part of the HSE team. The HSE-CRM questionnaire also included a complete set of "teamwork" questionnaire items. The domain score was calculated on a 100-point scale. Charts 1-7 illustrate that the average score of teamwork areas increased. Of course, the t-test does not show the level of statistical significance in some cases, however, it shows a significant improvement in the employees' understanding of teamwork after the implementation of the HSE-CRM project.

In this project, an attempt was made to make the education based on the obstacles, in a combined, interactive, and simulation form, and to some extent game-oriented. This style is new in its way. In addition to safety issues, first aid and safety protocols were also trained and practiced. In Iran, safety training is only a 2-hour session with a PowerPoint presentation, which some organizations hold for employees once a year or once every two years and not all people participate in these classes. Now, a style of training has been created that staff is eager to attend.

4. Limitations

There were several limitations to performing this project: There is no control group, so there is no confidence in the efficiency of this system, uncertainty to generalize it to other projects, low cooperation of top management levels due to a lack of belief in safety issues, and it is not possible to check the efficiency of the system under critical conditions.

5. Conclusion

Cultural transformation is possible even in construction projects due to its traditional structure, especially in Iran. For ultimate success with a large-scale HSE culture change program, ongoing leadership involvement and approval are required. In addition, a systematic study on the effectiveness of the intervention should be conducted to calculate not only the potential return on investment but rather, continuous feedback on potential improvement opportunities to be provided to frontline teams who are invested in providing the best possible care for staff in any setting. The results show that the

introduction of HSE-CRM tools to the construction industry is associated with a reduction in the time needed to monitor signs of problems by HSE Experts, assess work shifts by HSE Experts, and provide instructions and permits to work by HSE Chief. Also, related improvements in the HSE culture, which were measured by the questionnaire, can be mentioned in the results. The most important success in implementing SCR is related to reducing the time required by HSE Experts to collect and communicate critical information. Early identification of signs of an incident / near miss is critical because often HSE Chief's decision-making guides. In addition, participants said that intimacy and trust, communication and relationships between HSE department personnel and employees have improved. Successful working relationships between HSE personnel and other individuals allow all employees to have a shared focus on work, support each other during shifts, and provide a means to maintain timely and continuous communication about work conditions and incident response. The creation of protected time for HSE unit personnel is a reason for HSE culture change.

At the beginning of this project, staff and managers were uncomfortable with the change in traditional roles and questioned the unconventional nature of the project. But now the managers have noted that after 2 months, the efficiency, satisfaction, and support of the staff have increased. The improvement of the HSE culture in employee morale is the biggest achievement of this project. Factors related to the spirit of HSE culture are complex and varied. The result of this project highlighted several efficient factors of HSE culture morale that could be used by CRM techniques. However, recent literature has identified several predictors of nursing morale that may be more readily addressed with CRM techniques, such as Strong team interactions, ability to provide appropriate services, promoted level of team professional knowledge, and share in the success. With the creative application of these techniques, the organization could cause improved efficiency, a better understanding of teamwork, increased intimacy, empowerment, and improved morale. CRM techniques are transferable to other HSE units and roles and can improve HSE outcomes. For the forthcoming training, in order to align training with instructional principles would strive to apply simulator scenarios and VR/AR.

Declarations

Ethical Approval

This article is part of the implementation of a project for an organization. The relevant organization demanded the performance of a Safety, Health, and environmental (HSE) culture. In this process, no experiments or activities that endanger the lives of humans or animals have been carried out. It was a training process. It was decided to present each part of it as a separate article. Therefore, there was no need for Ethical Approval. "Not Applicable".

Competing interests

In this article, only the authors of the essay have financial interests. No organization or institution has financial interests. "Not Applicable".

Authors' contributions

Sohail Sadeghi, project administrator. Saman Sadeghi, executive assistant of the project

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Availability of data and materials

All the data of this article is included in the article itself. Any data related to this article is inside the article itself.

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Figures



Figure 1

Results of Teamwork with unit & HSE department

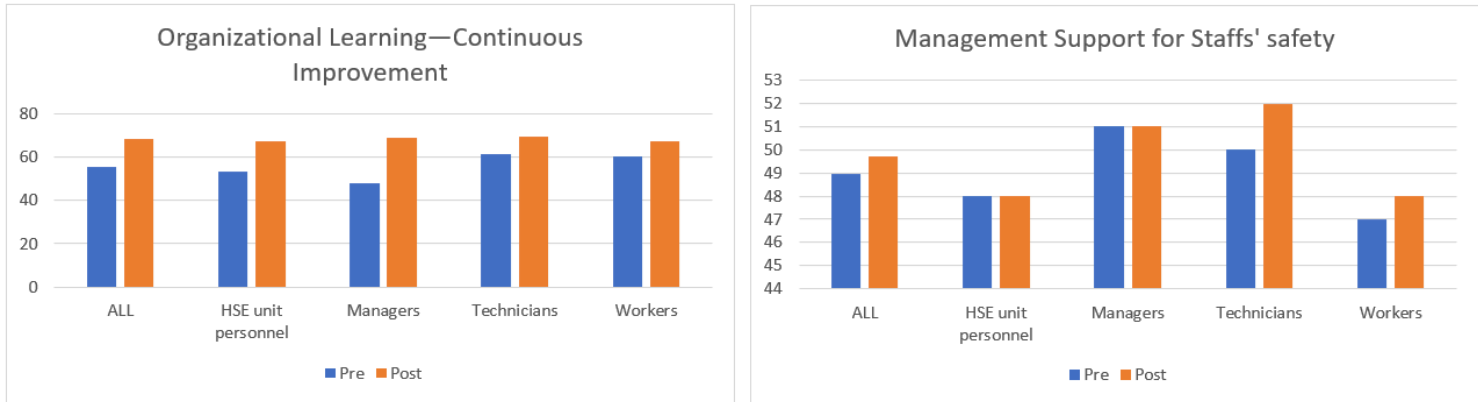


Figure 2

Organizational learning & Management support



Figure 3

Overall perception & Feedback

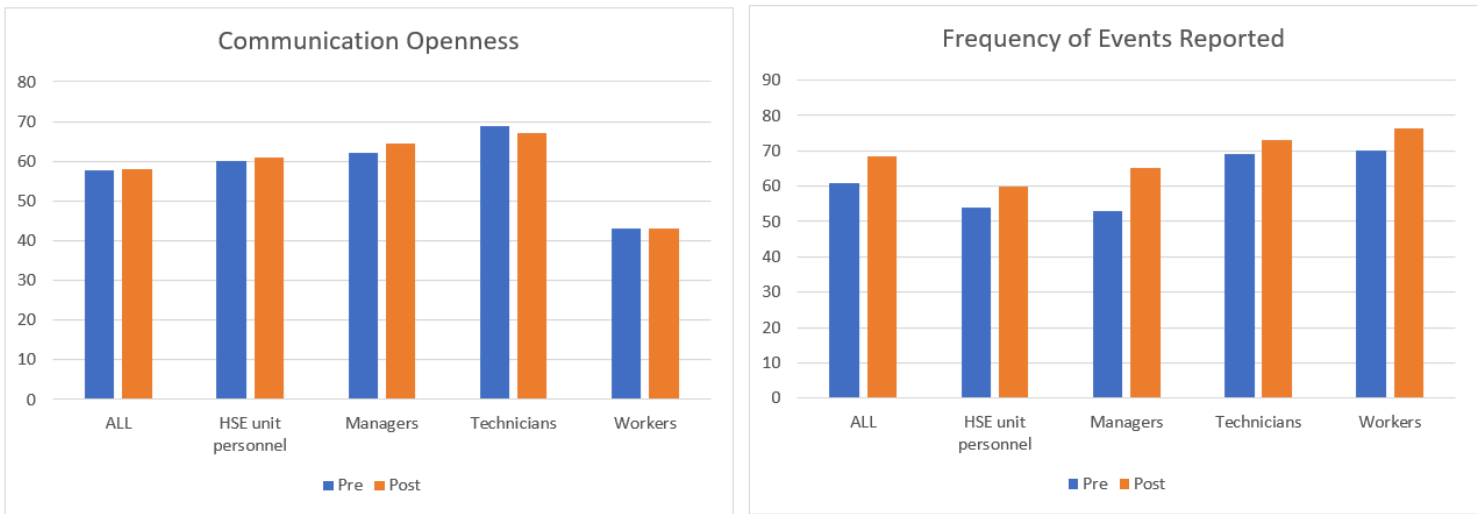


Figure 4

Communication openness & Frequency of events

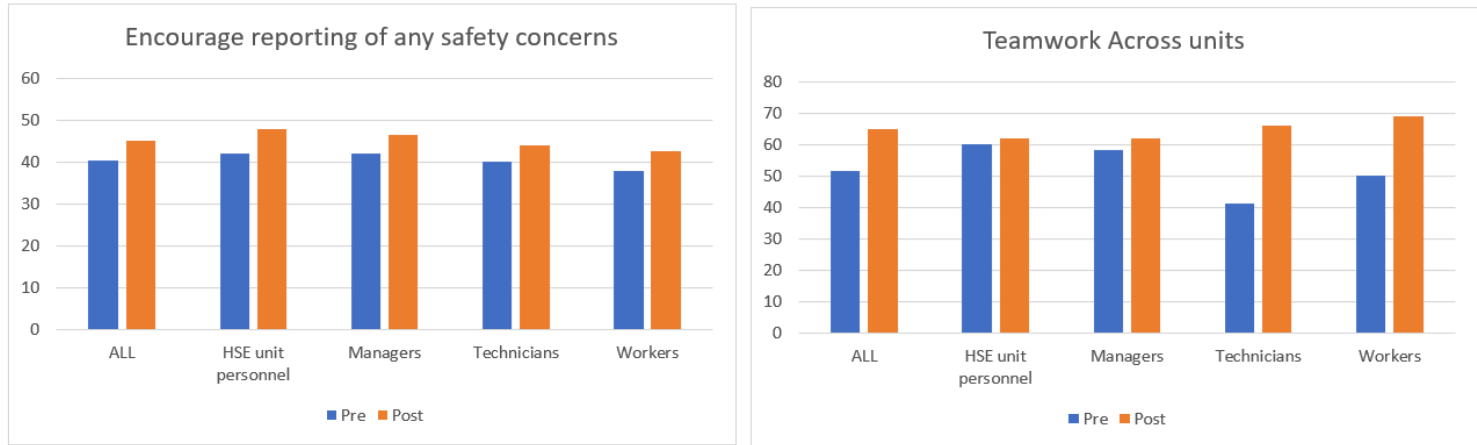


Figure 5

Encourage reporting & Teamwork across units

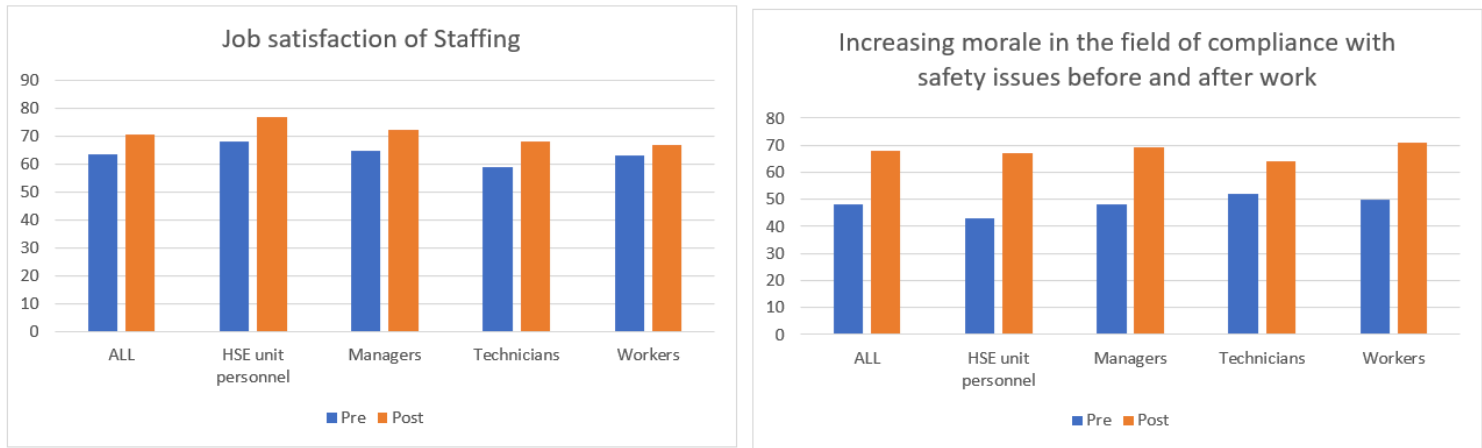


Figure 6

Job satisfaction & Increasing morale

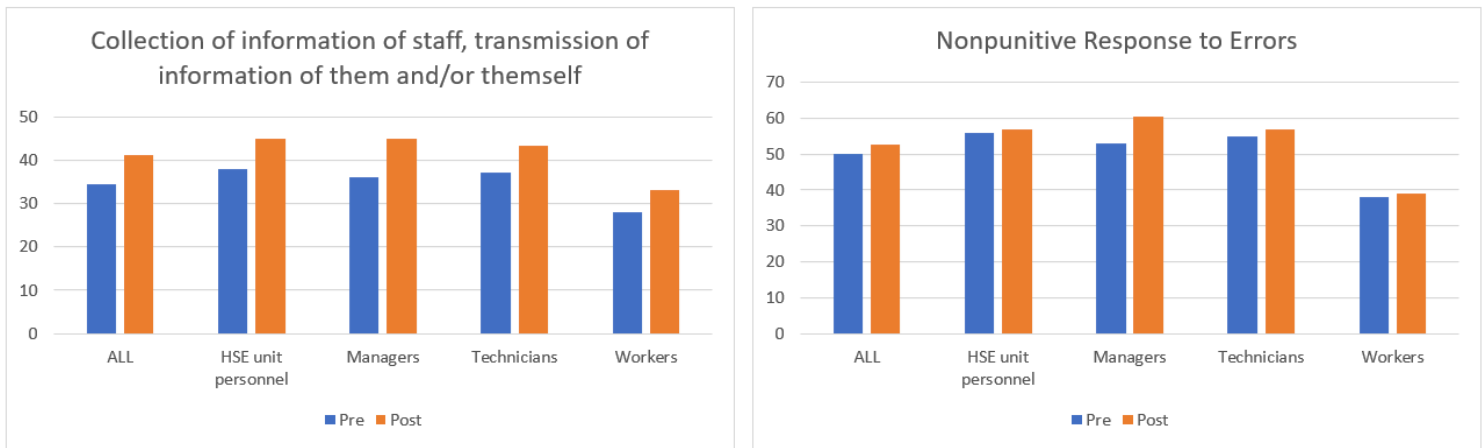


Figure 7

Collection & Nonpunitive response