Resilience through training – assessing cognition in teams

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ABSTRACT

Breakdowns in team cognition are accepted as an explanation for system collapses, especially in complex environments. In the nuclear industry, training for system collapses is a part of the job for control room teams. Such training focus both on improving skills required for recognising and solving disturbances and on improving team processes. This paper presents an approach to team training for nuclear power plant control room teams with the purpose of making the system more resilient by improving debriefing sessions through feedback on shared strategic understanding among team members.

INTRODUCTION

Nuclear power is generally considered as a very safe and environmental friendly approach to producing electric power. However, well-known nuclear power plant (NPP) accidents such as the Three Miles Island, Chernobyl and Fukuchima have shown that the rare accidents that do occur are subject to disastrous outcomes. Safety in nuclear power plants (as in most complex socio-technical environments) is a systemic effect that emerges from a number of interrelated processes such as maintenance, regulations, engineering, culture etc. However, when an incident actually occurs, the handling of that incident usually falls on the NPP control room team. A NPP control room is a complex environment designed to control complex processes that, if not handled correctly, might become dangerous and even have catastrophic consequences.

The responsibility of the NPP control room team is to produce electricity in a safe manner. In Sweden, this is done using teams that rotate shifts. That is, a team works as control room operators for a couple of weeks, have some vacation time, then receive training before returning to the control room. The teams are intact over each phase, i.e., team members are not exchanged unless necessary.

Control room personnel receive training in control room simulators, for both initial and continuous training. Traditionally this training comprises of several days of training for the team in the simulator training facility, an exact replica of the actual control room. The aim of simulator training is to operate the plant in a way that is reliable, safe, and professional. To achieve this aim the operators need to develop and maintain necessary knowledge, skills, and abilities. Training both focus on coping with the technical aspects of controlling the state of the nuclear power plant as well as other skills, such as communications, decision-making, and teamwork. Full scope simulators are used to develop and validate both emergency procedures and normal procedures.

The resilience engineering (RE, Hollnagel, Woods, & Leveson, 2006; McDonald, 2006) perspective is a recent approach to safety that draws attention to that any system will present a certain degree of performance variability, that is, a system's performance varies over time due to changes in control, external circumstances, and changes in system performance (for example, variation of skills in personnel over shifts, deterioration in material over time). Most of the time, performance varies within an acceptable envelope, whereas sometimes this variation is outside of the comfort zone. This is in line with fundamental theories in control theory that states that a controlling system must be able to present at least as much variation as the system it intends to control as "only variety can destroy variety" (Ashby, 1956). Traditional approaches to safety has mostly focused on after-the-fact analysis of accidents with the purpose of eliminating possible sources of unwanted variation by removing them or creating barriers to prevent unwanted interactions (Hollnagel, 2013). RE accepts that not all possible accidents can be foreseen and instead focus on finding ways to assure that the controlling system can present sufficient variation to cope with unforeseen variation. It is however important to remember that a balanced approach is to be preferred, where traditional approaches to safety are complemented with resilience-enhancing activities (Lundberg & Johansson; 2006; Johansson & Lundberg, 2010; Sheridan, 2008).

The most vital part of the NPP is the team of operators, as they are the human component in the system that contributes with problem-solving capacity, innovativeness and the ability to detect deviations in the NPP system state that lays outside of what has been foreseen by designers of automated responses and monitoring equipment. A team is defined as a set of two or more persons who are interdependent of each other and with individual roles, sharing a goal/s (cf Salas, Dickinson, Converse, & Tannenbaum, 1992). How a team manages to collaborate is dependent on what is labelled team cognition (Cooke, Gorman, & Winner, 2007).

Team cognition is "the cognitive activity that occurs at a team level" (Cooke, Gorman, & Rowe, 2009, p. 158). There are two main views on team cognition, the shared vision perspective and the interactive team cognition perspective (Cooke, Gorman, Myers, & Duran, 2013). The interactive team cognition perspective is related to team processes such as communication, cooperation, and coordination (cf. Swezey & Salas, 1992; Rousseau, Aubé, & Savoie, 2006). In order to effectively communicate, cooperate, and coordinate, a team needs to maintain a shared understanding of the shared goals (Rosen, Fiore, Salas, Letsky, & Warner, 2008). This can be done using the shared priorities instrument (Berggren, 2014; Berggren, Johansson, & Baroutsi, accepted). The shared priorities is an instrument developed to assess a team's shared strategic understanding. In the current case, the instrument was used as a basis team development during the post simulation training discussion. The instrument is administered by letting the team members individually generate five items that are important for the ***team*** to reach its shared goal/s. These items are then rank ordered, and a measure of concordance is computed (Kendall & Babington Smith, 1939).

Team training with the purpose of improving shared understanding and goal understanding in teams can thus be seen as a resilience-enhancing activity as it increases the potential of the team to cope with both foreseen and unforeseen variations in system states. Traditional training that focus solely on problem recognition and problem solving largely ignores aspects of team cognition, or at least do not assess or explicitly view shared understanding as an important contributor to successful performance. Instead, such training encourages procedure-driven behaviour. Procedure-driven behaviour is a good thing, as long as it is possible to recognise the situation at hand and apply a procedure to solve it, but when novel, unforeseen, situations occur, teams must have the ability to rapidly grasp the situation and formulate new goals and innovate ways to cope with the situation.

For NPP control room training in simulators, mostly the technical aspects are stressed (Ekström, 2015). In addition the *soft skills*, such as communications, decision making, and teamwork, are also trained. Full scope simulators are usually used to develop and validate both emergency operating procedures and normal operating procedures. Post-exercise discussions and briefings given by the instructors on the crews' performances are central to training. The instructors can give feedback at both an individual and a team level (IAEA, 2004). The function of feedback can have many causes, for example to reinforce behaviours and to reduce undesired behaviours, while alsoto motivate and to guide (Gabelica, Van den Bossche, Segers, & Gijselaers, 2012). For feedback to be effective it need to be goal- or task-directed, specific, and neutral (Thurlings, Vermeulen, Bastiaens, & Stijnen, 2013).

Purpose

This paper presents a case study of how the shared priorities measure can be applied to NNP control room crew training for post session discussion and feedback.

METHOD

13 Swedish control room crews participated in the study. There were 59 men and 4 women. Age ranged from 23 to 64 (M = 41 years). Some operators in the teams had worked together for several years, while other operators had been a part of their current team for a few months.

Material

To provide a basis for discussion of the control room teams' shared understanding the Shared Priorities instrument (Berggren, 2014; Berggren, Baroutsi, Johansson, Turcotte, & Tremblay, 2014; Berggren et al., accepted) was used. Other material was a questionnaire and post session group discussions with instructors and team members (Ekström, 2015). The post session discussion was held as part of the knowledge transfer and evaluation. Both team members and instructors participated. The discussion was moderated by the instructors.

The shared priorities instrument is administered by letting the team members individually generate five items that are important for the ***team*** to reach its shared goal/s. This was done during a pause in the scenario. These items are then rank ordered in order of importance. Here, the lists from each team member were presented next to each other during the discussion phase. This was to trigger the team members and instructors to consider differences among team members' perceptions of what was important. The idea is to advance the discussion focusing on the team's shared understanding to direct feedback towards team level issues.

Apparatus and scenario

A training scenario was conducted in a full scope simulator of the crews real control room. The scenario evolved around a breakdown in the reactor where one person had been seriously damaged by a leak in an injection tank. The wounded person was unconscious and needed immediate medical attention. The control room team is responsible for handling the situation. To handle the complex situation the control room team need to coordinate their actions and plan accordingly. The scenario deals with several team aspects such as shared goal, roles with different responsibilities, and interdependencies among team members (cf. Salas et al. 1992).

RESULT AND DISCUSSION

Diversity among the teams' outcomes from the shared priorities instrument was seen. Some teams were quite similar while other teams had a high degree of variation. The perceived experience of using the shared priorities instrument to develop training is presented, and then the outcome from the post session discussion is reported. The response to the question "Do you see any value in using the shared priorities instrument in training?" indicates that the respondents see value in using the shared priorities instrument to increase the training. The response to the question "Did Shared Priorities bring any added value to the discussion after the training session?" shows that the respondents believe that the use of the presented lists provided added value to the post simulator training discussion. The response to the question "Has Shared Priorities given you a better understanding of the team's shared goals?" expresses one aspect of what the team members found important, namely that the consideration of shared priorities does benefit the shared understanding of the team's shared goals. When the instructors were asked "Do you think that Shared Priorities contribute with something positive to simulator training?" the response is that this approach adds value for the instructors as well.

The post simulation training discussion revealed that both operators and instructors believed that the use of the Shared Priorities instrument could support the teams' nuclear power plant control room training in several ways. The teams see meetings and other disseminations of information during operations as an essential part of maintaining shared understanding of different situations. They also believe the instrument might help the teams reflect upon and develop their meeting procedures. Operators and instructors also expressed that by using the instrument it can help teams to increase their understanding of having a shared understanding and shared vision.

GENERAL DISCUSSION

The results presented in this paper reflect a positive attitude towards the use of the shared priorities instrument. This can be because the outcome of the shared priorities provides a structure for post-session discussion, arranging to the feedback discussions, and pointing towards differences and similarities within a team. In relation to the instructors' experience, these lists can also indicate that a team is focusing on aspects that are less important, and hence be instructed and trained to align with the expected standards.

During traditional training the feedback is incorporated into the post-session briefings. These are mainly concerned with technical skills and handling of the facility. Of course, interpersonal skills and teamwork is given attention, even though these aspects are less prominent. The shared priorities instrument offers the instructors something tangible to discuss and to relate teamwork aspects to.

Considering these findings in the light of team cognition, the outcome of the shared priorities instrument seem to add structure to the team training, mainly focusing on similarities and differences regarding shared strategic understanding among team members. The shared understanding of shared goals enables effective coordination and communication. That is, if team members are aware that other team members have a different view on what is prioritised they can adapt their behaviour accordingly. Similarly, communication can be used to maintain shared strategic understanding so that coordination and cooperation can be effective. The benefit for the nuclear power plant control room teams' training is evident considering the results. These teams benefit from a structure that supports the discussions to focus on teamwork, and hence maintain focus on the shared strategic understanding of the shared goals.

By encouraging, and assessing, the process of improving shared understanding in a team, resilience can be improved, as a well-established understanding of common goals is likely to support handling of unforeseen events. Irregular and unexpected events are difficult if not impossible to prepare for, and therefore demands a team that is well-tuned as such a team does not have to spend unnecessary time aligning among it's members.

We cannot see why the findings in this study would not be useful in other control room environments where teamwork is a central aspects of maintain operations and safety. In situations where the daily operations are dependent on teams to sustain business, in complex environments where the situations are changing dynamically, teamwork will be a central part of controlling the processes.

Future work

Applying the shared priorities instrument in another situation, such as an emergency/disaster training situation where a crisis response team is handling operations would be interesting to study using the shared priorities instrument outcome for feedback discussions.

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