Exploring the Importance of Reflection in the Control Room

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Abstract

While currently difficult to measure or explicitly design for, evidence suggests that providing people with opportunities to reflect on experience must be recognized and valued during safety-critical work. We provide an insight into reflection as a mechanism that can help to maintain both individual and team goals. In the control room, reflection can be task-based, critical for the 'smooth' day-to-day operational performance of a socio-technical system, or can foster learning and organisational change by enabling new understandings gained from experience. In this position paper we argue that technology should be designed to support the reflective capacity of people. There are many interaction designs and artefacts that aim to support problem-solving, but very few that support self-reflection and group reflection. Traditional paradigms for safety-critical systems have focussed on ensuring the functional correctness of designs, minimising the time to complete tasks, etc. Work in the area of user experience design may be of increasing relevance when generating artefacts that aim to encourage reflection.

Introduction

All control room operators work with a level of uncertainty, dependent on the quality of information available about the system being controlled. Reflective activities enable the monitoring of dynamic factors such as the extent to which the system can be trusted, and whether controllers have sufficient expertise and training to solve persistent problems. Experienced controllers have evolved a broad repertoire of techniques for encouraging reflection, including recounting tales to trainees and visitors as well as discussing situations among the team (Smith, Blandford & Back, 2008). The idea that technology can be used to encourage reflection in safety-critical domains is novel. We suggest that work in the domain of user experience design may provide leverage for designing such technology. We will consider how sensor technologies, the ubiquitous whiteboard, collaborative tools and ambient displays, could potentially be used to encourage and guide reflection. Initially, however, we highlight the types of reflective activities that need to be better supported in control rooms, and also consider implications from a sensemaking perspective.

Background

Relative to the ideas presented in this position paper, the work of Rochlin (1999) provides appropriate background. Rochlin draws on evidence from a range of studies of organizations in which safety is paramount to argue that safety is a constructed human concept, and that the evaluation of system safety cannot be reduced to the systematic evaluation of sources of risk. Back et al. (2008) identified that dealing with high risk events is facilitated by designs that provide operators with an opportunity to engage in reflection. Engaging in reflection can, for example, enable the generation of new artefacts (that facilitate communication between operators) or new procedures that increase the overall safety of the socio-technical system. An obvious intervention from an organisational perspective is to allow operators the freedom to be more reflective. Allocating more flexible role assignments, for example, may facilitate reflection on mundane routine work. However, fundamentally changing work practice that has evolved over many years should be approached with caution. Hildebrandt et al. (2008) highlight instances where senior controllers have become too involved in the work of others and neglect their responsibility to maintain a high-level situational overview. Such an overview is essential to ensure that all team members are coping. In a nuclear power plant control room, roles are tightly defined and tasks are procedural: there is little room for freedom. However studies have identified that avoiding potentially high risk situations, where the established procedures were inappropriate or not correctly executed, required the opportunity to reflect on experience (e.g., Perrin, 2005).

Instead of forcing changes to work practice, we suggest that technology should be designed to better support existing reflective practices. We propose that self-reflection and group-reflection should be designed to provide a means of *social sensemaking*, which we discuss below.

Social Sensemaking

In the control room, goals can be task-based, critical for the 'smooth' day-to-day operational performance of a ***system***. Ostensibly, the development of procedures that ensure the functional correctness of the system is of primary importance. However, when viewing the ***system*** from a human-centred perspective, procedures and training protocols are clearly not sufficient to ensure safe operation. This is because control room operators work with a level of uncertainty, dependent on the quality of information available about the system being controlled. Controllers need to reflect on experience to make sense of the system so that their uncertainty is reduced. One way of achieving this is to ensure that a controller understands what is expected of them as an individual when a potentially high risk situation arises. Simply thinking about the current situation is clearly not sufficient to engage in this type of sensemaking. Weick (1995) sees social sensemaking as both subjective and central to identity construction. Within the idea of group identity construction, he includes questions such as who they are, what they do well and poorly, what problems they face and how they might solve them. He stresses that these things are not 'given', but are the result of interpretive processes through which members come to share understandings about themselves.

A New Safety Culture: Developing Awareness of Oneself and Others

A good safety culture should foster learning and organisational change by enabling new understandings to be gained from experience. Weick observes how sensemaking is facilitated and constrained by the language that communities use in everyday interaction for noticing, interpreting and communicating significance. He also notes the way in which stories of unusual or extraordinary occurrences are used to communicate departures from conventional understandings. Stories are interesting just because they communicate experiences which are noteworthy in their departure from shared norms of experience. In contrast, established understandings, routines, and roles that help to maintain coordinated action impose an "invisible hand" on sensemaking. The sense that can be made is constrained by tradition as well as by the vested interest to sustain meanings that reflect favourably on the organisation. Consequently, organisations can fall prey to the failure to notice significant cues and situations where these fall outside a shared frame of reference. Increasing the reflective capacity of individuals and teams within an organisation is likely to encourage the re-examination of established understandings and routines. Moreover, an increased awareness of oneself and others can be used to promote new understandings by expanding the shared frame of reference. As a means of illustrating these ideas, we now present findings from a study conducted in a London Underground Control Room.

Representations for Inviting Reflection

The initial focus of Smith, et al.'s (2008) study was on understanding differences in both physical structure and organisation of work that might lead to different behaviours that achieve broadly the same outcomes. However, using an inductive approach to data gathering and analysis, it became apparent that the commonalities in practices were much more significant than the differences. Controllers argued that the skills and knowledge required in a control room cannot be taught, but have to be gained by experience in the actual situation. They would not accept that the training simulator could provide this. By being given a level of responsibility that may result in them making mistakes they gained opportunities to reflect on experience. Senior controllers reported that if a trainee suggested an incorrect action they would be allowed to carry that action out (provided that it would only impact on efficiency, and not on system safety). Clearly, providing people with opportunities to reflect on experience should be recognized and valued.

Teams within an organisation maintain multiple representations of the state of the socio-technical system. While these representations may appear contradictory (e.g., allowing trainees to reduce the efficiency of the system), to the system actors they are complementary viewpoints that together support reasoning and safe operations. Rochlin (1999) notes that safe organisations typically value the reporting of error, and regard breakdowns as being the responsibility of the organization rather than the individual. Rituals and stories serve to transmit operational behaviour. Smith, et al. observed that when changing shift, where controllers have to pick up each others' work, it would be expected that they develop an opinion on other people's skill. Observed teams seemed particularly comfortable with each other and reflective about their work. This demonstrates the importance of social sensemaking (e.g., increasing awareness of oneself and others) by engaging in reflective practices.

Task Level Reflection

Thus far, we have considered reflection as a mechanism that can foster learning and organisational change by enabling new understandings gained from experience. This type of reflection can help to determine, for example, whether controllers have sufficient expertise and training to solve persistent problems. However, reflective practices can also be observed that facilitate the 'smooth' day-to-day operational performance of a socio-technical system at a task level. For groups to work effectively there needs to be reflection between individuals and within groups. We believe that these issues could be explored further for design intervention in procedures, tools, representations, artefacts, and training and similar so that performance can be enhanced.

Reflection between individuals has been observed to take place so those individuals work better together. For example, in the London Ambulance Service control room individuals who work next to each other were observed to prepare for the oncoming work from their colleagues. In this case they were implicitly work-shadowing to be aware of oncoming demands to enhance performance. Buffering was also observed in the London Ambulance Service study (Blandford & Furniss, 2006; Furniss & Blandford, 2006) as it was on the bridge of a ship (Hutchins, 1995). Here, individuals who need to pass on information to a decision maker will make intelligent decisions about when to interrupt that person. For example, if the decision maker is busy and the information they have received is not relevant to the current task, and not critical in itself, then the decision maker should not be disturbed. They hold up the information, as a buffer, until it is convenient to pass it on. Another example of reflection between individuals was observed in an Technical Support Helpdesk setting where experts would reflect on the knowledge of the people they were talking to and adapt the amount of technical information they offered as explanation to gain a balance between informing and confusing (Savla, 2008).

Reflection in groups has also been observed to take place to maintain group goals and a collective awareness of the situation, and to perform group problem solving and decision making. Work on an agile software development setting revealed that the programmers would have stand-up meetings where everyone would stand at their desk and report the progress of their work throughout the day, presumably for group awareness and motivation (Sharp et al, 2006). Meetings were also an important part of dealing with events in a nuclear control room so the shift supervisor and operators are able to gather information and create a shared awareness about what to do next. Indeed, Klinger and Klein (1999) performed a study on the emergency response organisation (ERO) within a nuclear power plant and recommended a protocol to organise group reflection around five questions:

- What is the priority in terms of mitigating the event right now?
- What is the immediate goal?
- What am I responsible for (to be answered by each person at the command table)?
- What will this situation look like in 15 minutes?
- What are we most worried about?

User Experience Design

There are many interaction designs and artefacts that aim to support shared problem-solving, but very few that support self-reflection and group-reflection. Traditional design paradigms for safety-critical systems have focussed on ensuring the functional correctness of designs and minimising the time to complete tasks, etc. However, we have argued that systems should also be designed to better support existing reflective practices. Now that we have outlined a number of these practices, we highlight technologies that could be used to capture experience and encourage reflection. Work in the area of user experience design may be of increasing relevance when generating artefacts that aim to encourage reflection. Indeed, supporting users' emotional and social awareness seems to be central to supporting reflective practice. We consider sensor technologies, the ubiquitous whiteboard, collaborative tools and ambient displays, as being pertinent (*see* Table 1). We suggest that these technologies can be used to support awareness of oneself and others, representations that invite reflection, and reflection at the task level.

Table 1: Technologies that may support reflection

Novel Technology	Supports
Sensor technologies	Reflection on use can lead to awareness of ones own capabilities. This in turn may facilitate social sensemaking.
Ubiquitous whiteboard	Being aware of the way individuals within a group manage their goals may help with identity construction.
Collaborative tools	Encourages storytelling and the generation of new representations to invite reflection.
Ambient displays	Task level interactions that involve reflection may require support to ensure that they are not interrupted.

Sensor Technologies and Developing Awareness of Oneself

We use a personal account to show how sensor technology can support awareness and reflection: When first starting to use the treadmill at the gym I found the heart rate monitoring device quite novel. The machine would also tell me to slow down when my heart rate went up too high. Over time I got used to getting a feeling for when I was exerting myself too much, and would slow down and get my heart rate under control again. Interestingly, I found that I brought this new awareness and reflection to when I was road running, away from any monitoring device. The awareness and reflection that I developed with the monitoring device could be taken to the streets where I would slow down and get my heart rate and breathing under control, for example if I had just run up a hill or had been going to fast. Perhaps a similar monitoring device could raise awareness and reflection in different scenarios e.g. a stress monitor for air traffic controllers could alert them to when they needed help or when to employ strategies to de-stress. An awareness of the limitations of ones own capabilities may also provide leverage for social sensemaking. Knowing that at times people need to employ strategies to cope on a personal level, may provide a means of understanding what others do well and poorly, what problems they face and how they might solve them.

The Ubiquitous Whiteboard and Developing Awareness of Others

Observations in control rooms have revealed that whiteboards are frequently used to reflect (e.g., Garbis, 1999). The primary reason for using a whiteboard is not as a cue for remembering. Since the whiteboard is a shared artefact controllers can begin to develop a sense of awareness of how the team manages their goals. This facilitates a level of awareness that is critical for maintaining a situational overview. The use of a ubiquitous whiteboard, enabled as an interactive digital workspace, would allow transitions between goals to be represented. This is of special importance during shift handover since it is likely to stimulate storytelling between teams.

Collaborative Tools and Representations that Invite Reflection

A key issue in inducing reflection is the problem of fixation, in which people can become so entrenched in the solution they are working on that they lose all objectivity to evaluate the inherent strengths and flaws of their particular solution. Several key methods of overcoming fixation are the inducement of an incubation phase (Smith & Blankenship, 1991), as well as the use of multiple examples as a way to induce cognitive simulation (Dugosh et al., 2000). The use of an incubation phase posits that a solution may be easier to obtain if the users have a chance to step away from the problem and have a chance regain some type of objectivity in regards to the problem they are working on. The use of multiple examples is a way to promote cognitive stimulation by giving the user a wider palette of solutions to draw possible solutions from.

Technology could leverage these two strategies by providing a collaborative tool, such as a smart table, that would analyse the sketches and notes that users would be using to problem solve in a group dynamic. By disseminating and understanding the sketches involved, the system could determine a suitable time in which a requirement to reflect is needed. This can range from the mild intrusion of suggesting differing examples to the more intrusive in which a break period is enforced by giving a differing 'break' problem to allow users to benefit from the incurred incubation period. Introducing a smart table in the control room is likely to fundamentally change work practice. This is something that we do not wish to promote (we should be cautious about changing practice without developing a full understanding). A more appropriate location would be in a coffee break room. This type of technology is likely to be very useful when senior staff are informally evaluating the competencies of other team members or individuals that have not previously worked with a team in the past but may do in the future. The use of collaborative tools may provide new representations that invite reflection.

Ambient Displays and Task Level Reflection

Stand-up meetings and protocols designed to encourage reflection provide teams with a focus for engaging in reflection (*see* above). However, there may be situations where it is important to maintain awareness of what is going on in a control room without being overly distracted. For example, being distracted may interrupt reflective work-shadowing practices that are critical when anticipating oncoming demands. Ambient displays have for some time been proposed as a means of providing situated information in a manner that minimizes the invasive nature of traditional displays and reduces the distraction. In a nuclear power control room, operators often have a considerable amount of time to make decisions even in high risk situations (unlike aircraft pilots for example). Ambient displays allow the freedom to reflect without being overwhelmed by everything that needs to be addressed. But the flip side of this is that unstructured reflection might miss the critical points! So a balance is needed.

Conclusions

This position paper has suggested a range of technologies that may be useful to support reflective activities within safety-critical domains. Although it is clear that much more work is needed, this paper has argued that reflection and social sensemaking is vital to what people do in control room environments and should be better supported by HCI technology.

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