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A framework for learning from incidents in the workplace

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ABSTRACT

Learning from Incidents (LFI) in the workplace has been gaining increasing importance in the Health, Safety and Environment context. Although organisations adopt a variety of LFI initiatives, it is often unclear what learning approaches are the most appropriate and the most effective for different types of incidents across a range of contexts. The aim of the paper is to surface factors that are important for effective Learning from Incidents (LFI). The paper builds on a conceptual framework for learning from incidents, developed through an earlier study. This conceptual framework was validated through empirical data collected at two multinational corporations in the energy sector. From this data a refined framework for learning from incidents was devised with five factors important for LFI: *participants of learning, type of incidents, learning process, type of knowledge and learning context*. This framework can be used as an evaluation tool and as a guidance tool to develop holistic, organisational learning approaches.

1. Introduction

Learning from Incidents (LFI) in the workplace has been gaining increasing importance in the Health, Safety and Environment (HSE) context (Cooke and Rohleder, 2006; Lindberg et al., 2010). Effective learning from incidents can improve safety within an organisation. At the same time it can enhance organisational productivity, since safety and productivity are complementary, rather than competing, drivers within the energy sector.

A range of different factors contribute to the effectiveness of the organisational approaches to learning from incidents. Although organisations adopt a variety of LFI initiatives, all initiatives are not equally effective and efficient for a particular incident or context, nor is there a 'one size fit all' solution. Furthermore, the impact and effectiveness of LFI approaches that organisations use depends on the scope and the quality of these initiatives. Therefore organisations have to develop a better understanding of factors that would increase the effectiveness and impact of LFI initiatives.

In the literature, LFI is addressed from a Safety Sciences perspective. However, safety literature on LFI does not draw sufficiently upon existing theoretical insights and empirical research from the fields of workplace and organisational learning (Lukic et al., 2010). Furthermore, most current research on LFI views the dissemination of incident information as the most important aspect of learning from incidents (Gordon, 2008; Macrae, 2008; Sepeda, 2006). This standpoint overlooks important learning processes that occur throughout the lifecycle of an incident, from reporting and investigating to implementing changes in employees' behaviours or organisational procedures. Since the main focus is on dissemination of information, LFI disregards the variety of activities that might have a meaningful impact on the learning process.

The aim of this paper is to address this problem by drawing upon current literature and explore the issues through a qualitative study identifying factors that are critical for effective LFI. The study was carried out in the context of two large multinational corporations in the energy sector. The understanding of incidents used in this study included both negative safety events with actual consequences and near misses. Furthermore delineation was not made between process and personal safety incidents, relying on the respondents understanding of safety incidents. This study is a part of larger research project 'Learning from incidents: a social approach to learning from health and safety incidents in the workplace'[1]. Firstly, we outline a conceptual framework for learning from incidents that was developed through an earlier study (Lukic et al., 2010). Secondly, we report the results of an interview study in two organisations in which the framework was tested as a conceptual and methodological lens for surfacing issues and elements important for effective LFI. The conceptual framework was tested through a baseline qualitative study and the significance of specific factors was confirmed. Additional factors emerged through the study, including the 'learning context' and the 'depth and breadth of learning'. Thirdly, we present the refined conceptual framework for learning from incidents in organisations. Finally we outline implications for research and practice and propose future directions for research.

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[1] http://www.academy.gcal.ac.uk/lfi/index.html.

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2. The original conceptual framework for learning from incidents

In an earlier study we proposed a conceptual framework to inform development and analysis of LFI initiatives in organisations (Lukic et al., 2010). The framework is briefly discussed here to provide a context for the current study.

Based on a comprehensive review of the literature, our original conceptual framework included four important factors: learning participants, learning process, type of incident and type of knowledge (Fig. 1).

2.1. Participants of learning

To increase the effectiveness of learning from incidents in organisations, we must understand who should be included in the process of identifying LFI solutions and to what extent they should participate in the learning process. Both individual and organisational factors must be considered, therefore the concepts of inclusion and individual agency are of relevance (Billett and Pavolva, 2005). In terms of *inclusion*, a key question is: do the LFI initiatives involve individuals, teams or the whole organisation, or, indeed, the whole sector? The literature suggests that inclusion of participants from all organisational levels is important, emphasising that, although inclusion of 'shop-floor' staff is central, executive involvement is equally essential (Dyreborg and Mikkelsen, 2003; Cooke and Rohleder, 2006). Furthermore, it is important that LFI approaches take into account *individual agency* – the level of *engagement* of employees with each learning initiative (Billett and Pavolva, 2005) and their ability to challenge the status quo within the organisation (Bryson et al., 2006). Key considerations include the extent to which all stakeholders can influence and shape the learning process and whether they have opportunity to question organisational and systemic issues.

2.2. Type of incidents

Learning from incidents is sometimes oversimplified. Therefore the complexity of incidents is not always understood. Naot et al. (2004) argue that one of the reasons that learning from incidents can be low-level is due to the relatively superficial analysis process and overemphasis on implementation of lessons learned. Cooke and Rohleder (2006) noted the desire to find a single-root cause, sometimes termed 'root-cause seduction'. While accepting the importance of 'best practices', employees' own solutions and ideas are more appropriate for learning from specific incidents (Loud, 2004). When deciding on which LFI approach to implement, the nature and complexity of an incident should be considered (Delloitte, 2009). Also the relationship between the nature of the problems causing the incident and the learning solutions employed to address them should be explored. The 'Cynefin' framework provides an in-depth understanding of the complexity of an event. The framework distinguishes four domains of complexity that characterise an incident. These domains are 'simple' and 'complicated', (representing orderly domains) and 'complex' and 'chaotic' (reflecting 'disorderly' domains) (Snowden, 2002). The effectiveness of LFI is diminished if solutions designed for orderly situations are applied in complex or chaotic domains. In the *Simple* domain, cause and effect relationships are clear and solutions tend to be straightforward – usually in the form of 'best practices' that can be captured and shared. In the simple domain, one needs to determine the facts, categorise them and use the best-established practice when dealing with a particular problem. In the *Complicated* domain, causal relationships are not easily identified. An in-depth analysis is required to surface the issues. While causes may not be overt at an individual level, an

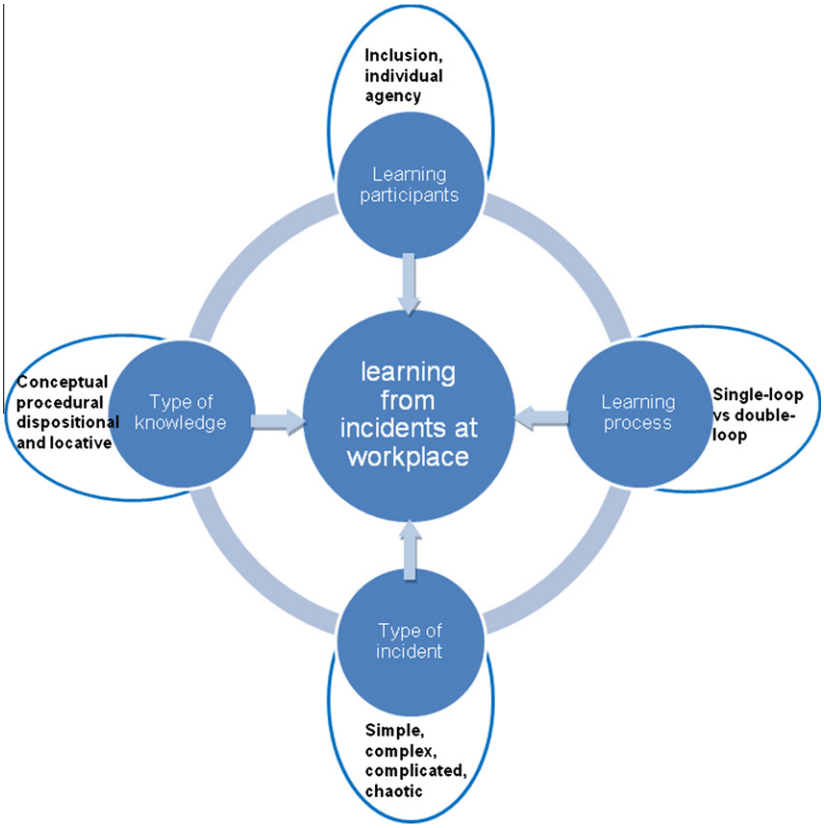

Fig. 1. The original conceptual framework for LFI (Lukic et al., 2010).

efficient solution usually exists and can be identified through further resources and experts following an in-depth analysis. Solutions in the form of 'good practices' (as opposed to 'best practices') are more effective in such situations. The *Complex* domain deals with situations where urgent action is needed and in which there are sets of interlinked causations. The causes are difficult to determine while the incident is taking place, but could be surfaced in hindsight after thorough investigation. In the *Chaotic* domain, incidents cannot be predicted. Little time is available for in-depth analysis and fast reaction is needed to mitigate the crisis. The aim is to shift the situation from chaotic state to complex, yet controllable situation (Snowden, 2002). Chaotic domain firstly require 'reflection-in-action' type of learning (Schön, 1996) and subsequently deep analyses and learnings typical of the other three domains.

2.3. Type of knowledge

It is important to take into account the type of knowledge required to address a problem and to prevent future incidents. Four forms of knowledge are central to learning: conceptual, procedural, dispositional and locative (Lukic et al., 2010).

Conceptual knowledge (''knowing why'' and ''knowing what'') relates to facts, concepts, information and propositions (Anderson, 1982). Conceptual knowledge ranges in depth from knowledge of simple facts such as names of equipment parts to a thorough understanding of how a work process functions and what principles underpin it. In the safety context it refers to the understanding of safety issues and incidents related to the processes and causes that lead to them. Deep conceptual knowledge is important because it allows complex problem solving as it enables an employee to understand the nature of the problem, and its relationship with other related problems.

Procedural knowledge (''knowing how'') comprises techniques and skills that enable one to enact conceptual knowledge (Anderson, 1982). Procedural knowledge is classified into three levels (Stevenson, 1991). First-order or specific procedures are activated to achieve specific goals or tasks that are usually automatically done. In novel situations, second-order procedural knowledge is utilised – the ability of individuals to monitor and evaluate strategy. Third-level procedural knowledge is concerned with higher-level monitoring of activities. Procedural knowledge is a core component of expert performance in the workplace.

Dispositional knowledge supports the development and building of conceptual and procedural knowledge and consists of attitudes, values, emotions, interests and personal motivations (Perkins et al., 1993). Dispositions are essential in putting conceptual and propositional knowledge in practice. Dispositions such as safety values or attitudes to wearing protective equipment can have strong implications for health and safety. Moreover, positive dispositions towards acquiring new knowledge are instrumental in learning from incidents in the workplace.

Locative knowledge (''knowing where'' and ''knowing who'') is a form of meta-knowledge about the location and sources of relevant knowledge (Nicholls-Nixon, 1997; Norris et al., 2003). It can relate to resources and tools as well as people and practices as the source for gathering other types of knowledge. Likewise, it can relate to locating knowledge both within the organisation and outside of it (other organisations, expert networks, etc.). This type of knowledge is usually acquired through networking and interactions with others, as well as through training. Employees should know where to find the knowledge they need to deal with safety incidents in the most effective manner (IBM Institute for Business Value studies, 2009).

Learning process LFI initiatives should be underpinned by a solid understanding of learning processes. There are a range of conceptualisations of such learning processes. Argyris and Schön's (1996) outline two modes of learning, double-loop and single-loop learning, which could provide a useful conceptual basis for LFI. Single-loop learning includes solutions to errors in the organisation by correcting the immediate and superficial causes of the problem. Examples of single-loop approaches include 'quick-fix' actions that companies use for addressing incidents. These approaches include technical corrections, skills training and disciplinary actions. However, the nature of incidents is more complex and there is usually a complex system of immediate and deep-rooted causes that lead to an incident. The process of investigation and learning from incidents is most effective when all layers of complexity are unravelled (Kletz, 2001) and corrective actions to rectify the situation are identified. This requires a more thorough learning process. In contrast, double-loop learning is based on open inquiry into deep-rooted causes, system failures and organisational values. This mode of learning questions the underlying assumptions of organisational work (Argyris and Schön, 1996). Double-loop learning aims to change organisational factors and culture that often cause incidents (Spear, 2002). In the theory of single and double-loop learning, there are two models that guide human action. They are namely *theories-in-use* that can be inferred from observable actions or *espoused-theories* that people claim are guiding their behaviour. Argyris and Schön highlight the gap between these two models: they argue that often espoused-theories contradict theories-in-use. What people claim or even believe are their guiding theories of are often very different from the values and principles manifested through their behaviour in the organisation. This contradiction is sometimes reflected in so-called 'blame-game' attitudes to learning from safety incidents. Rose (2004) suggests that the desire to learn from incidents is significantly diminished' whenever a culture of perceived risk minimisation and blame avoidance is established within an organisation, (p. 468). Ego-protection behaviours prevail and employee's actions at all levels, from grassroots to senior management, are frequently guided by defensive ('saving-face') mechanisms (Argyris, 2004).

The original conceptual LFI framework, that can be used to analyse approaches to LFI in organisations, was applied, tested and validated in testbeds in two large multinational companies in the energy sector. The framework is illustrated in Fig. 1.

3. Methodology

3.1. Data collection

Data was gathered from two sites at two multinational corporations in the energy sector. Site 1 was a refinery and site 2 was a gas plant.

The aim was to explore the four conceptual factors identified from the literature review and to surface any further issues. There were two phases to the data collection: the pilot and main phase. The aim of the pilot phase was to test the instrument and ascertain if the data gathered corresponded to the aim of our study. Post pilot phase, the interview script was revised to focus on informal learning and on the motivations of employees to engage with LFI. Data from both the pilot phase and the main phase were incorporated into the analysis. The interviews were audio-recorded, transcribed and anonymised prior to analysis.

3.2. Instrument

Data was collected through semi-structured interviews, which lasted 50 min (on average). The order and form of the questions were not uniform to allow respondents flexibility in their responses and to identify emerging themes. A typical interview script is included in Appendix 1. Interviewees were asked to describe a

Table 1
Interviewee roles.

Site	Pilot phase	Main phase	Shop-floor employees	Mid management	Mid management with core safety jobs	Total
Site 1	11	11	14	6	2	22
Site 2	5	10	11	3	1	15
Total						37

'critical incident' in health and safety in their work practice. The interview discussion was focussed around the incident(s) the respondent had experienced and described in order to (a) explore the company processes and practices in place after an incident and (b) elicit respondents' perceptions of LFI. The interviewee would then be encouraged to discuss other LFI initiatives at the site and describe the factors they perceived would influence the effectiveness of the process, participation and behaviours of employees on site. Emphasis was placed on issues and ideas raised by the respondents, so questions from the interview script were semi-structured and used only as a guiding tool.

3.3. Respondents

There were 37 participants in total (Table 1). The sample was derived through a combination of stratified and convenience sampling method. Respondents were recruited from various organisational levels to ensure broad representation: they included 'shop-floor' employees (operators, contractors), control room technicians and mid-management staff (field leaders, shift superintendants) and safety mid-management (safety engineers and experts). Participation was voluntary and interviewees were familiarised with the project. Participants were asked to sign a consent form.

3.4. Analysis

The interview data was analysed through content analysis. Interviews were coded and analysed thematically in NVIVO, using both predefined and emergent codes. The 4 general themes arising from the original conceptual framework for LFI (Fig. 1) – learning participants, learning process, type of incident and type of knowledge – were predefined. However, emphasis was on emerging themes and codes arising from participants' own perceptions and views.

4. Results

4.1. Participants of learning

In both organisations, the respondents indicated high level of inclusion of participants in LFI initiatives, especially initiatives that focused on the dissemination of information, such as safety alerts and bulletins through board posts and emails. However, the extent of inclusion (and involvement) appears to vary in other initiatives such as investigation reports or Toolbox Talks (special meetings where issues of safety and previous incidents are discussed). Although safety meetings and investigations usually involve the dissemination of key learning points across the organisation, workers' participation in these initiatives is limited. Interviewees emphasised that their full involvement in these initiatives is an essential factor for effective LFI and that they wanted even greater participation. The relevance of a particular initiative to the job role of an individual is also something to be taken into account when deciding on including employees in learning initiatives. A significant number of safety alerts, particularly those coming from other sites, are filtered and forwarded only to those employees for whom they are considered to be relevant. Although the majority of our respondents indicated that safety incidents unrelated to their work could yield important learning points, there was a concern that, due to time limitations, it is difficult to pay attention to all initiatives that are not directly related to each employee's work. There seems to be a contradiction between the need for increased inclusion and a concern about information overload. Deciding who to include in learning initiatives is an important factor in LFI. It would be useful to provide opportunities for all employees to decide what information could be important for them and how their learning could be monitored.

Issues extend beyond the involvement of employees. Even where a learning approach is very inclusive in its scope, employees may not have an active role to play in the learning process. Interviewees ascribed high importance to the opportunity to participate fully in an LFI initiative and to influence decision-making. They indicated high motivation to engage with safety learning. Their motivation and engagement was influenced by their concern for the safety of them-

Table 2
Formal and informal LFI initiatives at the two sites.

Safety initiative	Description	Type of learning	Site 1	Site 2
Database reporting system	An online system through which incidents can be reported and stored, with actions arising from each incident	Formal	Yes	Yes
HSE sheets	Individual booklets containing sheets through which hazards and safety issues are reported	Formal	No	Yes
Investigation	A thorough investigation process comprising a range of methods, e.g. after-action reviews (AAR) or root cause analysis (RCA)	Formal	Yes	Yes
Toolbox talks	Discussion sessions where safety issues are discussed	Formal and informal	Toolbox talks are a key means of rolling out LFI	Toolbox talks are a part of the work-permit meeting prior to start of the shift
Shift takeover	Transfer between shifts, recorded in logs or carried out verbally	Formal and informal	Yes	Yes
Safety meetings	Meetings at various levels of an organisation dedicated to safety issues	Formal	Yes	Yes
Email dissemination	Safety alerts and safety bulletins raising awareness of incidents and learning outcomes arising both from on-site incidents and the external ones	Formal	Yes	Yes
Personal communication	Communication between employees, office talk, private discussions	Informal	Yes	Yes

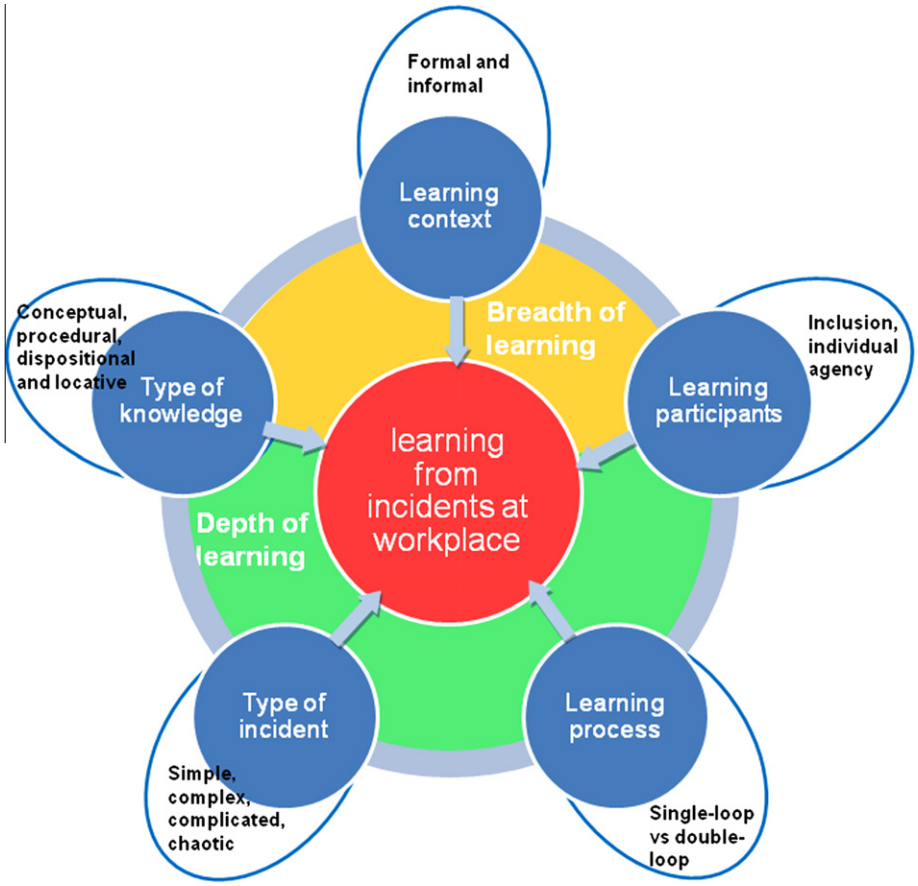

Fig. 2. Revised framework for learning from incidents in the workplace.

selves and others, the value the company attached to their contributions, feedback that the company provided on their suggestions and the organisational attitude to safety. Regular input from workers who are dealing on daily basis with complex issues could be a valuable way forward. Interview data highlighted that receiving response from the company on feedback that the employee provided can positively influence employees' motivation and willingness to exercise their individual agency. However, poor feedback and low opportunity to view the impact of one's engagement with LFI reduces motivation to engage in LFI. It appears, therefore, that *individual agency* is an essential component of learning from incidents and is important in ensuring employees take ownership of safety processes (Cooke and Rohleder, 2006; McElhinney and Heffernan, 2003).

4.2. Type of incidents

The majority of learning initiatives at the testbed sites focused on the dissemination of good or best practices. Although these approaches are useful as a means of sharing information and 'lessons learned' (Bond, 2002; Gordon, 2008) they are not the most effective approach across all situations. Most safety incidents are complex, with differing underlying causes. Full root-cause analysis investigations have the greatest scope for identifying the real nature of an incident. Respondents suggested that, in root-cause analysis investigations, the complexity of incidents should be considered and that learning actions that correspond to the nature of the incident should be devised. However, they reported a tendency within organisations to condense the learning points into simplistic, 'bullet' points or one-sentence statements, indicating a 'root cause seduction'. Such over-simplification may result in the loss of deep contextual meaning and limited relevance of learning points arising from an incident investigation.

When deciding on the format of the LFI initiative, organisations do not appear to take into consideration the complexity and type of the problem causing the incident. Our data indicates that, at both testbed sites, insufficient attention was paid to choosing learning approaches appropriate to the level of complexity of the problem, favouring solutions more appropriate for simple problems (e.g. best practice solutions).

4.3. Type of knowledge

Our data indicates that the majority of the safety learning initiatives address primarily conceptual and procedural knowledge. Many respondents expressed a need for more conceptual knowledge and understanding of how the whole process at the site works. One respondent emphasised that it was not necessary to know the underlying concepts if pre-agreed procedures were followed. Locative knowledge was reflected in informal communications, such as information or advice about a particular safety issue from more experienced colleagues. Some respondents indicated that they consulted online databases, web-based networks and previous incident reports. Data from both testbeds suggests that dispositional knowledge is not taken into consideration by organisations when selecting a learning approach.

The data suggests that poor attention to knowledge gaps and to the types of knowledge required to address incidents appears to affect employees' engagement and motivation, especially when they already know the information they receive through the dissemina-

tion of learning or when this knowledge does not relate directly to their work tasks. It would appear that the knowledge disseminated through LFI initiatives at both testbed sites was decontextualised: the particular context of an incident that spurred the learning initiative was not fully described nor was the significance of the work context considered. This poses problems for the transferability of these types of knowledge and reduces their potential impact. Overall, LFI initiatives primarily focus on procedural, and to an extent, conceptual knowledge.

4.4. Learning process

Most learning initiatives displayed characteristics of single-loop learning. In terms of moving towards double-loop learning, interviewees at both sites emphasised a notable improvement in the way blame-free organisational attitude is promoted and enacted in their organisations. Blame-free attitudes open the space for the organisational and systemic issues to be questioned so that deeper level learning and solutions can be sought. However, the 'blame-game' still appears to take place. Respondents noted discrepancies and contradictions in the reporting of incidents investigations. Some suggested that, although management may claim the main aim of investigation is to learn, the possibility of disciplinary actions can limit openness and transparency. Ensuring consistency of actions following an investigation is particularly important for LFI. 'Blame-game' attitudes can extend beyond the lifetime of a safety incentive; studies have shown that the effects of an incentive can disappear in an average of three months, yet negative experiences, such as recriminations, can impact behaviour for up to two years (Sveen et al., 2007).

Interviewees highlighted the influence of ego-protection routines on LFI. We found evidence of low incentive to openly share information about small-scale events (those that do not cause large-scale disruption, but are considered an embarrassing mistake by those involved). These small-scale near-misses could potentially cause more serious events in the future (Heinrich, 1931), therefore it is potentially dangerous for such small-scale events to remain undetected.

Inquiry into deep causes of incidents and systemic issues does not seem to be taken into consideration in most learning initiatives across the testbed sites. Full-fledged root-cause analysis investigations can surface deep causes. Our study indicates these are not conducted in every instance and, when they are, they do not always question organisational and management factors. Aside from investigations, LFI initiatives do not tend to be open for questioning and discussion by employees, which is characteristic of single-loop learning. However, the data surfaced examples of individuals reflecting on learning shared through alerts and toolbox talks as well as examples of raising their concerns with those responsible for safety learning within their organisation. Naot et al. (2004) suggest that transparency, integrity, inquiry, issue-orientation and accountability are all important in the implementation of double-loop learning in organisations.

4.5. Learning context

In addition to the four factors identified in the original conceptual framework, one further factor was indentified through the interview data. Learning context emerged as an important factor for effective learning from incidents. The learning context requires consideration of the extent to which LFI initiatives should be formalised (Beckett and Hager, 2002). In the context of learning from incidents, formal learning would represent structured systematic initiatives deployed by the company with learning as a specific objective. Most LFI initiatives are formalised within organisational safety procedures and processes. Learning from incidents is often enacted through formal reports, meetings and presentations to management (Shedden and Ahmad, 2010). By contrast, informal learning, takes places through the course of work tasks, where learning is not always an explicit objective. The line between formal and formal safety learning initiatives is not so strict, as many formal and systematic initiatives can be followed by informal sharing and learning. Table 2 gives an overview of the LFI initiatives identified at the two sites, in which the study was conducted.

Our study indicated formal learning in learning from incidents is perceived to be more valid than informal learning, since it is verifiable by experts (safety engineers, shift superintendant, etc.). More employees recognise they are learning in formal settings than in informal contexts. By contrast, informal learning can be spontaneous and natural, allowing employees to talk more freely about an incident or a near miss than in formal safety processes. A problem with informal LFI approaches is that the discussions and communications where learning takes place are not easily captured, codified and reused. Informal information sharing is individual-specific and can be lost when an employee changes role or leaves the organisation. Therefore, although informal discussions carry important learning points, these ideas are rarely disseminated.

The findings suggest that formal and informal LFI approaches have both benefits and limitations. Therefore, the degree to which initiatives are formalised is an important consideration when developing LFI approaches. A key question is – can the structure, accessibility and quality control of formal learning build on the spontaneous, open inquiry typical of informal learning? Despite the potential benefits of integrating formal and informal learning, the testbed sites tended to focus on formal learning initiatives, which, in some cases, were inadvertently implemented in a superficial way, rather than as an effective mechanism for learning.

5. Discussion

Our results suggest that four factors (Fig. 1) identified through a desk study were confirmed as important for LFI in the views of our respondents. Based on the results of our empirical study, we revised the framework for learning from incidents (Fig. 2). The original framework devised through a desk study (Lukic et al., 2010), had four associated factors. These were supplemented by a fifth factor emerging from the empirical data – the learning *context*. These five factors overlap to a degree and supplement each other (Fig. 2), which is aligned with Neavestadt's (2008) idea of necessary redundancy of frames of reference needed for proper improvement in safety. Therefore the framework allows for tight coupling of concepts and issues related to learning from incidents.

The inter-relationships between the five factors of the revised framework can be linked to the breadth and depth of learning. The *breadth of learning* is represented by the top three factors within the framework (Fig. 2): participants and level of learning, the format of the learning and the types of knowledge. The breadth of learning includes a variety and scope of learning related to safety employed at the site. For maximum impact, all activities related to safety should have as wide a scope as possible. It is also important to consider how deep and transformative the learning is and to what extent it brings about significant change in organisational processes and human behaviour. The four lower factors within the framework represent the *depth of learning* (Fig. 2). Learning process and the associated concept of double-loop learning as well as the type of incident and its relation to the learning approach are all essential components for deep learning. Moreover, the factors of 'participants of learning' and 'types of knowledge', present factors that straddle both the breadth and depth perspective.

The proposed framework encourages broader thinking around LFI, through which learning from incident initiatives are viewed in relation to each other. After indentifying their learning potential,

safety initiatives should be integrated into a coherent LFI system. This sort of systematic integration of holistic learning approaches is supported by the concept of triple loop learning in organisations (Flood and Romm, 1996). Triple-loop learning from incidents suggests that, after reviewing the depth and breadth of learning approaches at a particular site and once gaps have been identified, these initiatives should be linked within a coherent system. Learning effectiveness should be the main aim of such system development. Such a systematic approach would avoid creating silos of knowledge with an organisation and would increase the effectiveness of LFI initiatives.

The results of the study have both theoretical and pragmatic implication. In terms of theoretical importance the proposed framework model links concepts from different aspects of LFI and provide for an interdisciplinary and holistic understanding of effective learning from incidents as a process. The revised framework for learning from incidents could serve as an analytical tool to evaluate LFI initiatives in organisations and to ensure that learning from incidents is wide, deep and holistic. Each initiative aimed at learning from incidents could be mapped against the five identified factors and their breadth and depth could be analysed for potential improvement. Equally, the framework can surface gaps in a company approach and behaviour in LFI and provide stimulus for measures to be taken to rectify them. However, addressing the shortcomings is a significant challenge for the organisations. The operationalisation of the factors of our framework to ensure LFI initiatives are both meaningful and impactful is an issue that needs further research. This will be investigated in the 'intervention' phase of the project, when the researchers and the employees will work collaboratively to develop solutions to the challenges highlighted through this study.

6. Conclusions

Few LFI initiatives in the testbed sites address all these important factors of learning from incidents. From the empirical data we identified that employees should have greater involvement in all LFI initiatives and that they should have opportunity to have an input into the learning process. Secondly, the complexity of an incident or a near miss should be reflected in the learning approaches adopted to address those events. Thirdly, the learning process should have better inquiry into systemic issues and challenge organisational defensive routines to achieve double-loop learning. Fourthly, in addition to procedural and conceptual knowledge, more attention should be paid to locative and dispositional safety knowledge of employees at the sites. And lastly, formal and informal learning activities should be integrated.

Our proposed framework for learning from incidents (Fig. 2) provides a holistic view of LFI, in the context of the whole cycle of an incident. It can be used to promote contextualised learning from safety incidents coupled with sense making and reflection. The findings are relevant not only to learning from safety incidents in the energy sector but also to learning from problematic situations in all types of organisations. The framework can be used as an evaluation tool and to provide guidance for developing holistic organisational learning approaches in a wide range of companies.

6.1. Limitations of the study

The results are based on respondent's perceptions around learning from incidents, rather than on actual LFI outcomes, which limits the findings. The relative small size and diversity of the sample imposes further limitations on the breadth of the findings. The study would have benefitted from greater involvement of senior managers, to elicit and include their views. Further research could gain insights into operationalising the LFI framework and measuring its impact on practice.

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Appendix A. Questions guidance for the semi-structured interviews

Background
1. Describe briefly your work.

Critical incident
2. Can you remember a particular incident or near miss that you experienced here? What did you do/what was done in that situation?
3. In what way could you/others learn from this experience?
4. What process was followed to learn from this incident?

Safety learning initiatives
Formal
5. What safety learning initiatives are you aware of?
6. Can you give your input? In what way?
7. Are they relevant? Do they give information relevant for your work?
8. Who decides on the relevance and inclusion? What do you think about it?
9. What influences the amount of time and effort you can put into learning from incidents?
10. Are people open about learning from incidents? How about blame and disciplinary measures?

Informal
11. Do you share these experiences informally, talking with colleagues?
12. How does the shift take-over happen?

General ideas about variables that influence learning from incidents
13. What is your perspective on human error?
14. What influences people to report incidents and near misses?
15. In what ways can the learning from safety incidents be improved at this site?

Questions added after the pilot phase
16. How about sharing positive experiences in safety?
17. Do you think that you could learn from different types of incidents not related to one's work?
18. What influences people to engage in learning from incidents?

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