

KNOWLEDGE TRANSFER AS A CRITICAL COMPONENT FOR PROMOTING A POSITIVE HEALTH AND SAFETY CULTURE

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Within the last decades the incidence of workspace injuries and fatalities in the UK construction industry has declined significantly. However, the labour market is changing and to retain experts and attract new talent, the organisations need to cultivate healthier, safer and happier working environments. This can be achieved by cultivating positive occupational health and safety (OHS) culture on construction sites, which is a challenge, considering multiple health and safety behaviours and organisational cultures across the different firms involved in construction projects. Formal and informal knowledge transfer (KT) processes can: prevent the loss of critical knowledge due to the changing nature of construction work; reduce OHS risks; contribute to behavioural change and cultivation of OHS cultures across organisations. The focus of this research is the factors that facilitate OHS knowledge transfer in and between organisations involved in construction projects. This paper contributes to the body of knowledge by demonstrating inconsistency in OHS culture and lack of alignment between OHS and KT systems in construction firms, which hinders learning from good practices, incidents, near misses and failures between projects, from projects to programmes and across supply chain.

Keywords: Knowledge Management (KM), Knowledge Transfer (KT), Occupational Health and Safety (OHS), Positive Safety Culture, Construction Industry.

INTRODUCTION

Literature on occupational health and safety (OHS) in organisations and issues of organisational learning and knowledge management (KM) have gained increasing attention (Doytchev and Hibberd 2009, Nesheim and Gressgård 2014, Shereihiy and Karwowski 2006, Wahlstrøm 2011). Studies on the application of KM principles in OHS across different industries, including aviation, mining, nuclear and construction

exist, however they are fragmented and lack recommendations on practical applications (Podgórski 2010, Shereihy and Karwowski 2006).

The UK's construction industry is a complex and safety-critical industry with a wide range of enterprises starting from sole-traders, small and medium enterprises to multi-nationals working on construction projects under contract and sub-contract to a main provider (Office for National Statistics 2018). Effective OHS management often constitutes a big challenge for many organisations, which operate under pressure to deliver short-term results. This is particularly the case on the client side of project and programme execution (cf. Brady and Davies 2004). In the construction industry every project is essentially a temporary organisation that engages various actors from different firms, which results in challenges in inter-project knowledge transfer (KT) and reuse. Establishing a culture of KT in construction firms is especially difficult due to its uniqueness, fragmented nature and complexity of programme and project operations.

There are health and safety regulations, norms and guidelines in place (Shereihy and Karwowski 2006), however, the regulations do not include safety-specific guidance suitable for different working environments. Organisational learning of OHS will not be complete if it is based only on learning from generic safety guidelines and safety regulations provided by governmental bodies. Transfer of tacit knowledge that considers specific work context is especially important for risk management and hazard identification, particularly in high-risk industries (Podgórski 2010).

There is a shared understanding amongst academics and practitioners of the importance of organisational and cultural dimensions for facilitating KT (APQC 2013, 2016, Davenport and Prusak 1998, Duryan and Smyth 2018, Senge 1990, Szulanski 2000). Organisational routines, organisational culture and informal KT and reuse are crucial for learning in and from projects (Bartsch et al. 2013, Mueller 2015).

This paper is drawn from wider research which explores the policies, practices and experiences of Occupational Health and Safety (OHS) in the UK. Here, an exploration of the factors that facilitate OHS KT in and between organisations involved in construction projects. The findings demonstrate an inconsistency in OHS culture and lack of coordinated KM strategies in the UK construction industry.

LITERATURE REVIEW

Knowledge management

The vast majority of scientific papers on KM look mainly at information systems and the human dimensions (Jashapara 2011). Although the term 'knowledge' does not have a broadly accepted definition, in the field of business management it is considered as a "fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of knowers. In organisations, it often becomes embedded not only in documents or repositories, but also in organisational routines, processes, practices, and norms" (Davenport and Prusak 1998:5). There are three levels of knowledge: individual, organisational and structural (Edvinsson and Malone 1997).

Individual knowledge (often tacit), resides in human minds. It is obtained through experience and is difficult to transfer to others. The term 'tacit' knowledge was first coined by Polanyi (1962: 4) as very personal knowledge: "we know more than we can tell". Tacit knowledge is "developed and internalised by the knower over a long

period of time, and is almost impossible to reproduce in a document or a database” (Davenport and Prusak 1998: 70). Thus, consideration of human and social factors is crucial for knowledge flow through the organisations.

Structural knowledge is formal (explicit), easy to access, codify and store in databases, reports, procedures and other organisational documents (Nonaka 1991). Organisational knowledge is a result of a learning process. According to Polanyi (1967) knowledge in organisations exists along a continuum between tacit and explicit knowledge.

Considering that only part of tacit knowledge can be converted into explicit knowledge (Polanyi 1962, Davenport and Prusak 1998), and also that codification of tacit knowledge requires investment and may result in paying more attention to formal knowledge (Podgórski 2010), it is important to have a system in place to manage both, tacit and explicit knowledge.

Knowledge Management and Occupational Health and Safety

Knowledge plays a central role in implementation of an effective OHS management system (Shereihiy and Karwowski 2006, Törner and Pousette 2009). There are governmental regulations, norms and guidelines, documented in explicit (passive) forms, that need to be followed (Shereihiy and Karwowski 2006). However, those regulations do not include all possible safety issues that are specific to different working environments and are tied to different work contexts. Organisational learning of OHS will remain incomplete if it is based only on explicit knowledge that exists in the form of accidents records, safety guidelines and safety regulations. Tacit knowledge may be especially important for risk management and hazard identification and accidents’ prevention particularly in high-risk industries (Podgórski 2010).

It is widely acknowledged that a learning culture has a major role to play in cultivating safety culture within an organisation (HSE 2005). There is no one-size-fits all model for OHS KM and firms need to develop their own models of transferring tacit and explicit knowledge (Shereihiy and Karwowski 2006). They need to cultivate an environment of continuous and proactive learning at all levels. Shereihiy and Karwowski (2006) emphasise the importance of creating awareness on the importance of managing knowledge for OHS, learning from similar organisations and identifying the most important target areas for learning and developing OHS KM strategy. Wiig (1997: 229) suggests KM initiatives must “rely on people-related mechanisms such as storytelling, communities of practice (CoP), and social networking”.

Knowledge Transfer for Occupational Health and Safety in Construction Firms

There are two levels of KM in construction firms: management of project knowledge and management of knowledge within individual firms (Kamara et al. 2003). Knowledge transfer or KT can be defined as “the process through which one unit (e.g., group, department, or division) is affected by the experience of another” (Argote and Ingram 2000, p. 151). Knowledge can be transferred through processes of socialisation, education and learning (Argote and Ingram 2000; Roberts 2000). Smyth et al. (2019) posit that safety management systems are largely information-based while knowledge management systems in construction, albeit very partial, are disconnected from OHS at both formal and informal levels of operation. Therefore, KT in a construction context has still to be developed. A basis is examined below.

In some papers on knowledge management, the terms knowledge sharing (KS) and KT are used interchangeably, however according to Tangaraja et al., (2016) the former is a subset of the latter. KS refers to knowledge exchange between two

individuals, a sender and a receiver. Although KT incorporates people-to-people processes through personalisation, it is not an entirely behavioural concept, as opposed to KS. KT encompasses both behavioural and non-behavioural features and can be achieved through personalization (identifying, recognising, sharing, acquiring/absorbing and applying) and codification (identifying, recognising, acquiring/absorbing and applying) (Gera 2012, Tangaraja et al. 2016). KT is more complex than KS and can occur at different levels: individual, group, product line, department/division and organisation (Paulin and Suneson 2012). It emerged as a response to a need for new ways of managing knowledge to learn about best practice in increasingly complex organisations (Crawford et al. 2016).

Considering that multiple organisations are involved in construction projects, KT across organisational boundaries at both, programme and project level and between the projects requires a degree of alignment of the organisational cultures. The capture of the information and knowledge on safety risks and hazards and its transformation into knowledge capital with further efficient KT within and amongst the organisations, can significantly influence problem solving and decision making on OHS. However, there is no sufficient evidence in the literature on successful usage of KM principles in managing OHS (Podgórski 2010).

According to Health and Safety Executive (2008), it is important to achieve a critical mass of awareness to trigger behavioural change and worker engagement across organisations. KT between leadership teams operating in different levels of the organisation and among the projects enables organisational learning.

The forms of explicit KT are important, however, tacit knowledge, embedded in the workers' minds, is necessary for building trust and encouraging safe behaviours (Roberts 2000, Shereihy and Karwowski 2006). Concepts of knowledge transfer that isolate knowledge from practice have been criticized by learning theorists (Lave and Wenger 1991).

There are tools like CoP, narratives or storytelling, after action reviews and workshops that can support OHS related tacit knowledge exchange. Storytelling, or narratives, are considered as a natural method of knowledge transfer (Podgórski 2010, Sveiby 2001). In high-risk organisations, learning of safety rules presented through stories is faster than via trainings or instructions (Aase and Nybø 2005). This is especially useful for new hires and young employees, who need to learn about safety culture in the organisation. Storytelling proved to be effective for simulation of rescue actions to train those responsible for rescue operations in the US mining industry (Vaught et al. 2006).

Health and safety messages can be enhanced by the use of images and videos that demonstrate the accidents to deliver the message across to usually unresponsive groups of workers (Bust et al. 2008). According to HSE report (2006) construction workers tend to believe that accidents will always happen to other people. The stories about the accidents on sites, that had a life-changing impact on employees and their families, who are going through pain and suffering, can send through a very powerful message and help others recognise their own vulnerability (HSE 2006).

Construction is a knowledge-intensive industry, however management by objectives and hierarchically structured social relations, especially in large infrastructure organisations, discourage KT (Senge 1990).

Organisational culture

The concepts of organisational culture and climate have been developed to understand social environments. According to a comprehensive definition by Schein (2004: 1) organisational culture is “both a dynamic phenomenon that surrounds us at all times, being constantly enacted and created by our interactions with others and shaped by leadership behaviour, and a set of structures, routines, rules, and norms that guide and constrain behaviour”. Based on Cox and Cheyne (2000), organisational climate is a temporal manifestation of culture that is reflected in the shared perceptions of the employees at a particular point in time. It lacks clear categorization and is subject to direct control (Jashapara 2011).

As defined by HSE (2005), the term ‘safety culture’ can be used to refer to the behavioural and situational aspects of firms, while the term ‘safety climate’ should be used to refer to feelings, attitudes and perceptions of employees in regards to safety within a firm.

De Long and Fahey (2000) provide evidence that organisational culture creates norms regarding what is ‘right’ and ‘wrong’ in the organisation and influences how people communicate and share knowledge. It has the potential to induce a shift from a transactional “knowledge is power” to the more transformational mental model of “knowledge sharing is powerful” (Dalkir 2005).

Positive health and safety culture

It is generally accepted that behavioral and social scientists broadened and deepened understanding of OHS by studying 'safety culture' and 'safety climate' (Denison 1996, Zohar 1980, Neal et al. 2000, Lee and Harrison 2000). 'Safety culture' resides at a deeper level, while 'safety climate' is its surface expression' (Wamuziri 2011). The concepts emphasize the importance of collectively defined social context that develops over time. 'Safety culture' is a subset of organisational culture, where the norms, beliefs and values are shaped around the matters of OHS.

The Health and Safety Executive (1991, 2005) emphasises the importance of cultivating a positive OHS culture in organisations. Organisations with a positive safety culture are characterised by shared perceptions of the importance of safety, by communications that are based on mutual trust and understanding, and by confidence in the efficacy of preventive measures (HSC 1993). A positive safety culture requires effective top-down, bottom-up and horizontal communication on safety (HSE, 2005; Wamuziri 2011). This implies that senior managers have a significant role to play in shaping organisational culture through the messages they convey and the way they behave under pressure (Schein 2004, Wamuziri 2011).

Support from senior management plays also a crucial role in creating an environment for learning from past and current mistakes without a fear of blame and in driving behavioural change (Carrillo 2013, HSE 2008, Nesheim and Gressgård 2014, Duryan and Smyth 2018). An appropriate system for transferring safety information and knowledge is especially critical in smaller companies because of the lack of safety knowledge.

Occupational health and safety culture in construction

The UK construction has over 314,590 organisations (Office for National Statistics 2018), is a complex and changing industry operating within high-risk operational environment. The industry is formed of a wide range of enterprises from small and medium to multi-nationals working on construction projects under contract and sub-

contract to a main provider (Office for National Statistics 2018). The dominant project culture in the organisations that manage discontinuous and dissimilar projects, adds to complexity of the industry. There are underlying subcultures in construction organisations shaped by the groups of professionals “who bring their own culture to the table, even if all contributors are in-house to the client organisation” (Walker 2015: 161).

Over the last two decades, closer attention has been paid to the concept of a OHS culture in the UK’s construction industry (Sherratt et al., 2013). According to the report "Construction statistics in Great Britain" (HSE 2018), for the last five years the fatal injury rates remain at 1.64% per 100,000 workers. The main reasons for deaths are falls from height (47%) and injuries from being trapped by something collapsing or being struck by an object (12%). 58,000 cases of work-related injuries were registered in the period 2017/2018 with over seven days of absence (24%) and over three days absence (30%).

Although there is a significant decline in work related injuries and fatalities in the UK construction industry within the period of 2000-2012, the rates of decline have slowed (HSE 2018), suggesting that the industry needs a deeper analysis of the underlying causes of injuries and fatalities that lie in the behavioural or cultural domain. Cultural change is necessary for construction organisations if they plan to bring about improvements in OHS performance (Wamuziri 2011).

Construction projects are complex technologically and culturally as they are shaped by the groups of professionals from other organisations across the supply chain. Thus, robust OHS programmes and systems within a single enterprise may have little or no influence on improvement in OHS across supply chain and in the industry. In order to bring changes across the fragmented supply chain, there is a need for clarity concerning responsibilities for OHS among all actors.

The firms need to ensure that health and safety lessons are transferred between a singular project and the programme management level with further transfer to other projects (e.g. Carrillo 2013). KT across organisational boundaries at programme and project level and between the projects will require a degree of alignment of the organisational cultures.

Organisational culture that promotes trust and rewards employees for OHS KT, or a ‘just’ culture, may allow achievement of balance between blaming or not blaming someone for unsafe behaviours (Reason 1997). Whittingham (2004) refers to that kind of culture as an ‘open culture’ which acknowledges mistakes are made, and prioritizes reporting and learning from them. Failures challenge norms and beliefs embedded in organisational DNA and promote greater introspection and analysis of what went wrong (Jashapara 2011). In an ‘open’ cultural environment employees pay more attention to the inconsistencies of the outcomes that may have been overlooked in the environment of ‘blame’.

METHODOLOGY AND METHODS

The focus of this paper, which is drawn from wider research that explored the policies, practices and experiences of Occupational Health and Safety (OHS) in the UK, is on the factors that facilitate OHS KT in and between organisations involved in construction projects. The researchers focus their attention on organisational culture, where people are viewed as members of social systems with consideration of the dynamics of their interactions that influence KT.

An interpretative methodology is used in this research (e.g. Miles and Huberman 2002), which is appropriate for a topic embracing tacit aspects of knowledge transfer and application. Construction firms provide the unit of analysis in a case-based approach (e.g. Yin 2009).

The first phase of the research involved pilot interviews with six representatives of main contractors followed by a workshop with industry representatives. The data from the pilot study and the workshop were analysed to identify the most relevant themes, single out most interesting companies to study, refine the interview questions and define the key directions for a wider research on OHSW that involved also questions around KM and KT practices for OHS.

The following phase involved conducting semi-structured interviews at different levels, from operatives to senior level management. This paper draws on 32 interviews in three client organisations, three main contractors, two subcontractors, two sub-subcontractors and one self-employed operative. One interview was conducted with an independent industry adviser to understand how the institutions in the UK are addressing OHS. All interviews were conducted in the UK, however not all firms are UK owned.

The interview notes were examined for the presence of information about organisational routines related to KT for OHS in and between the organisations involved in construction projects.

A cognitive mapping technique was used to map the interviews. A cognitive map is a two-dimensional directed graph (Figure 1) that represents the issue from the perspectives of an interviewee. The concepts in the nodes are expressed in the interviewees' own language; and the meaning of every concept is contextual. The links between the nodes on the cognitive map represent logical implications between the concepts. The map enabled the capture of key statements in a hierarchical manner able to demonstrate the implication links among them (Eden and Ackermann, 1998). It also enabled structuring of the shared beliefs of all interviewees regarding transfer of knowledge for OHS. The map allowed understanding of why a situation is problematic and what can be done about it (Eden 2004).

Decision Explorer software (<http://www.banxia.com>) was used for the analysis of the cognitive map. The map can be analysed along two principal dimensions, the content and the structure. In this paper, the head, domain and centrality analyses of the merged map were conducted to identify the goals and key strategic directions as perceived by the respondents.

The heads of a map are the concepts represented by the nodes that have only arrows going inside. They demonstrate the goals expressed in terms of final ends or effects (Eden and Ackermann 1998). Domain and centrality analyses were used to identify the key issues in OHS KT. The nodes with complex domain (high density of links) are considered to be the potential key issues from the perspectives of the interviewees (Eden 2004). By analysing only immediate domain of the concept by itself, the wider context of the map is not considered. Centrality analysis extends the domain analysis by considering also indirect links. It measures the complexity of the concept's implication chain (the greater the complexity, the more central is the concept), and allows a more accurate view of key issues. Concepts with the highest centrality scores usually strengthen the ideas expressed by concepts with the highest domain score. If a concept appears in both analyses it confirms its position 'at the core of a potential key issue' (Ackermann and Eden 1998: 405). Those concepts, the emergent issues

(underlined on Figure 1), can become the subjects for a deeper elaboration and are presented in Table 1 in descending order of importance.

FINDINGS AND ANALYSIS

The cognitive mapping technique allowed structured presentation of the perceptions of interviewees on the role of KT for a better OHS performance. The analysis of the map identified 15 emerging issues, or key strategic options framed to achieve the goal that is 'improve OHS' (Figure 1, node 1). The emerging issues or strategic directions: 'cultivate a positive OHS culture', 'cultivate a culture of learning' and 'manage knowledge on OHS' directly contribute to achievement of the goal as perceived by the interviewees (Figure 1 & Table 1, nodes 22, 36 and 2 accordingly).

Positive OHS culture

According to the interview with the Industry Expert and Chair of Professional Body, the management of OHS in the industry can be distinguished by the size of construction firms. Large firms have stronger OHS culture, competent health and safety professionals and internal KM system which however is not aligned with OHS system, which contributes to the differences in KT practice in the back office and at the front-line. The smaller end of the industry mainly lacks OHS competence.

The respondents from the firms demonstrated a shared understanding of the importance of a positive culture for better health and safety performance and its impact on managing knowledge for health and safety (node 2) through the culture of learning (node 36).

An awareness of the cultural differences between contracting organisations emerged during the interviews. The underlying subcultures in construction projects are shaped by professionals who bring with them not only their expertise, but also their culture towards health and safety behaviours (Auch and Smyth 2010, Walker 2015). They prevent development of standardised approaches to OHS and require understanding of the informal routines.

There was agreement among the interviewees that one of the key elements of a positive culture is line manager's awareness of safety climate in their teams (node 28). The respondents from one of the sub-contractors noted that safety on sites is dependent on the management team working on that specific site and less on the company itself. Line managers are the ones, from the perspectives of interviewees, who encourage safety behaviours through their behaviours, instructions, counseling and support (Nesheim and Gressgård, 2014).

Another factor that contributes to cultivation of OHS culture is moving from 'having the right tools to building a culture that will promote right behaviours' (node 72). The managing director of a main contractor believes that to reduce safety risks to zero organisations investment in behavioural safety programmes is needed to encourage employees' discretionary behaviours.

Employees' responsibility for their own health and wellbeing (node 56) was recognised as another key element in ensuring cultivation of a positive OHS culture.

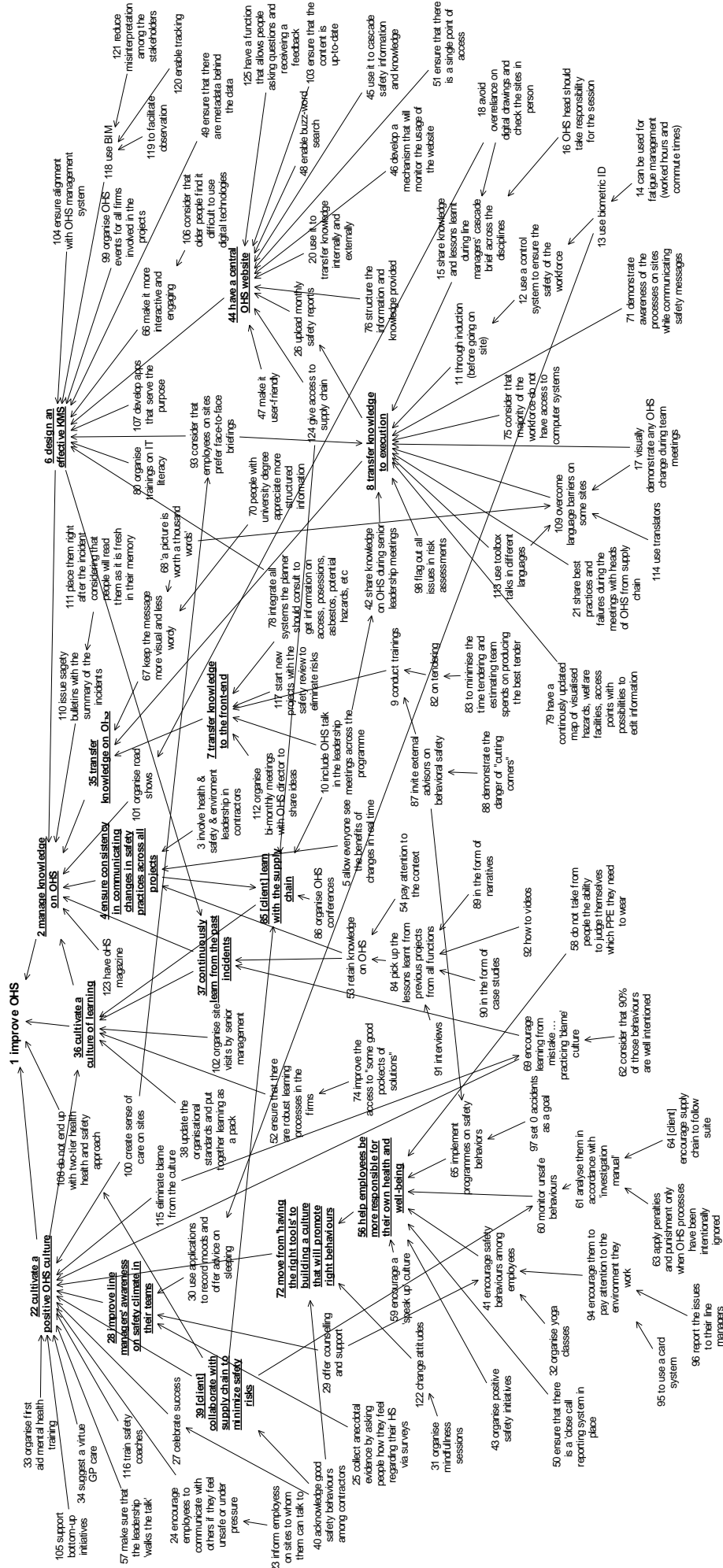
An OHS change programme manager of the infrastructure client organisation argued that individuals rely on the client organisation to ensure their safety. They assume that working site is 'a safety zone' as everything is taken care of: "I think we have taken away the need to think. We produce all these processes and procedures and rules and do not encourage people to think about their safety and wellbeing. Health and safety

and well-being carry behavioural element and we need to ensure that people understand that they are responsible for their lives".

Behavior-based safety management systems has a big impact on improvement of safety performance across the construction industry (Lingard and Rowlinson 1997). Overall there was a general consensus among the interviewees regarding the need to better understand behavioural factors that affect safety in construction. Construction firms need to increase their employees' ownership for safety by providing OHS trainings that consider the specifics of the workspace culture and include tacit knowledge sharing.

'Blame' (node 115) in corporate culture is another challenge for the organisations that want to improve safety performance. According to the interviewees, 'blame' and 'macho' culture discourages raising concerns regarding fatigue, stress, and other health and safety issues.

Figure 1



The same OHS manager emphasised the role of the client in reducing or eliminating ‘blame’ in the culture and mentioned that organisations need to change the attitudes and then relevant safety behaviours will follow. However, he posits a ‘no blame’ culture is dangerous as careless behaviours need to be addressed, especially in safety-critical industries like construction: "There is a need to shift from ‘no blame’ to ‘just’ culture because if there is no blame, there is no incentive to do things right".

All accidents, particularly severe ones, have a substantial element of human behaviour. People make choices that lead to negative consequences. Cultivation of a ‘no-blame’ culture in organisations is considered as one of the key factors that influence safety behaviour on sites (Carrillo 2013, HSE 2005, Kamara et al. 2003).

OHS learning and knowledge management

It was acknowledged by all respondents that positive health and safety culture creates a favourable learning environment and supports OHS knowledge management and transfer.

Noticeably, the concept ‘manage knowledge on OHS’ (node 2, Figure 1) has the highest centrality score, which demonstrates consensus among the respondents on the importance of managing knowledge on health and safety for improvement of OHS performance.

As demonstrated by the map, cultivation of the culture of learning directly contributes to KM on OHS (nodes 36 & 2). To sustain a culture of learning, organisations need to continuously learn from the past incidents (node 37), systematically update organisational standards (node 38), encourage senior managers’ visits to construction sites and improve learning and collaboration across the supply chain to minimize safety risks (nodes 39 & 85).

Learning from past incidents will eventually contribute to knowledge retention and management. However, a ‘blame’ culture discourages learning from mistakes. Employees should be encouraged to raise issues or concerns without fear that they will be blamed (Carrillo 2013, HSE 2005).

As the CEO of a main contractor mentioned, systematic learning from incidents and near misses is crucial for safety culture in construction organisations. He also emphasised the importance of learning from other industries: "If being a mindful organisation is what we strive to be, we need to embed the learning in what we do. The aircraft industry is a good example of learning from history".

Table 1: The key emerging issues/strategic directions (in descending order of importance)

The concept
[Node 2] manage knowledge on OHS
[Node 6] design an effective KMS
[Node 37] continuously learn from the past incidents
[Node 22] cultivate a positive OHS culture
[Node 36] cultivate a culture of learning
[Node 8] transfer knowledge to execution
[Node 44] have a central OHS website
[Node 85] [client] learn with the supply chain
[Node 35] transfer knowledge on OHS

[Node 39] [client] collaborate with supply chain to minimize safety risks
[Node 72] move from 'having the right tools' to building a culture that will promote right behaviour
[Node 7] transfer knowledge to the front-end
[Node 4] ensure consistency in communicating changes in safety practices across all project
[Node 56] help employees be more responsible for their own health and well-being
[Node 28] improve line managers' awareness on safety climate in their teams

Learning and collaboration across supply chain has been mentioned by the interviewees as an important contributing factor to developing a positive safety culture. However there is a lack of mechanisms in place to learn from such practices.

The other client demonstrated better practices in collaboration and mutual learning with its supply chain. The organisation, as a client, initiates regular safety, health and environment leadership team meetings with all contractors at an early stage of the portfolio management. Any changes in safety practices, lessons learnt from good practices, 'near misses' and failures are shared during these meetings. The contractors then take responsibility for cascading knowledge and information acquired in these meetings down to the project levels. The health and safety and security manager of the same client mentioned: "As a client, we recognise that we are in a powerful position where we can set the tone... We have got this chance to change things with our partners". This implies that safety is certainly not a competitive variable.

All interviewees agreed on the leading role clients and main contractors play in shaping safety culture and behaviours and ensuring consistency across Tier 1 and Tier 2 supply chains. An electrical project engineer from one of subcontractors agreed: "It is important that a strong main contractor manages the relationships between the contractors and makes sure they do not end up with a two-tier health and safety approach".

There was a shared understanding among interviewees on the importance of capturing knowledge on safety risks and hazards and transferring it to the project levels (node 35). There is however, acknowledgement of the lack of KT between leadership teams operating in different levels of the organisation and among the projects, which hinders inter- and cross-organisational learning.

Knowledge Transfer to the front-end and execution stages of new projects

The interviewees were asked about the transfer of knowledge on health and safety to the front-end in planning new projects (node 7) and to the execution stage for new projects (node 8). Some of the interviewees mentioned there is an established practice for safety review at the front-end of new projects to eliminate risks. Bi-monthly meetings with OHS directors and the leadership meetings across the programme facilitate tacit KT on health and safety. However, this practice is unsystematic and inconsistent across all organisations and projects.

According to the map's structural analysis, there are more consistent KT practices (where they are) during the execution stage of new projects (node 8, Figure 1). OHS knowledge is transferred during senior leadership meetings, during the meetings with heads of OHS from the supply chain, inductions and team meetings and managers' cascade the brief across disciplines. The head of health and safety in a client

organisations stated knowledge is usually transferred in the middle or at the end of the project.

A positive safety culture requires effective top-down, bottom-up and horizontal communication on safety (HSE 2005). The most popular way of cascading new knowledge or information on OHS to the sites, is through morning briefings. Bottom-up KT on health and safety issues on sites occurs through a card system that is further shared with the line manager. Operatives interviewed in one of the main contractors were quite positive with the feedback they receive on their health and safety reports. One of them mentioned that all safety or health issues are taken seriously and the actions follow in a timely manner.

According to the feedback from the client organisations, health and safety lessons are transferred between the project and the firm levels. But the main issue is they are still in a silo of one project and there are no mechanisms to transfer lessons across projects.

There are other challenges in KT to the execution stage related to language barriers on sites (node 109, Figure 1), most acutely in London. As HSEQ manager in a subcontractor mentioned: "language barrier poses a big issue because it can be very dangerous... There is one interpreter for every five people. The interpreter is often far away on site and they do not speak or even read in English so you may tell them something or correct something that they are doing in English and they will not understand". The interviewees recommended translating the key health and safety messages to all languages used on sites and using more visuals (how-to pictures and videos), rather than texts.

There are KM systems (node 6, Figure 1) in large construction organisations for the transfer of explicit knowledge on health and safety. Based on the responses, there are pockets of consistent practice in transferring information on OHS internally and across supply chain however, KM systems, where present, not linked to OHS systems (see also Smyth et al. 2019). It is also important to consider the majority of the workforce on sites do not have access to the internet and some do not engage with the IT systems for knowledge transfer.

CONCLUSIONS AND RECOMMENDATIONS

This paper has emphasised the conceptual challenges and practical issues of applying KM and organisational learning principles. Based on the analysis of the interviews, there is a shared understanding in the industry that knowledge is an important intangible asset to the firms that can assist in achieving better and more consistent safety performance. There is an emphasis on tacit KT through people-to-people communication, considering that some knowledge and experience on safety is difficult to codify. There is however, acknowledgement of the lack of KT between leadership teams operating in different levels of the organisation, between the projects and the functions.

There are pockets of consistent practice in transferring knowledge on OHS internally and across supply chain, especially in large construction firms. KM systems, where present, are not linked to OHS systems and a KM strategy is not a part of organisational strategy (see also Smyth et al. 2019).

The presence of subcultures, hierarchically structured social relations and management by objectives inhibits implementation of a cohesive safety culture in construction firms. The systems and culture remain weak and undeveloped in this respect, therefore more effort could or should be made by construction firms to

develop robust strategies for OHS KT, overcome variation in the OHS and move past the current plateau reached in safety statistics.

Governmental health and safety regulations, norms and guidelines do not include all possible safety issues specific to different working environments and tied to work contexts. Construction firms need to build relationships of trust and cultivate a culture of continuous learning at all levels. However, it is a challenge to cultivate a positive safety culture that will trigger behavioural change and worker engagement across construction supply chains in an industry known for a culture of blame, self-interest and opportunism.

Context related safety experience and cognitive skills of employees alongside the synthesis of facts and physical experiences are crucial for providing higher safety levels, encouraging innovative thinking and attracting new talent.

Intra- and inter-organisational routines are required to provide a crucial tie between different project-teams and to encourage tacit KT and reuse (Grabher 2004). Studying examples of the role of CoPs, social networking, storytelling or narratives in improving OHS management can be particularly useful. In this context the stories, visual narratives and videos that can become powerful tools for effective communication on OHS in ways that are relevant to construction workers, especially in multicultural teams (Bust et al. 2008).

The role of the clients is crucial for encouraging their supply chain to go beyond the transactional exchange of information and engage in collaborative relationships that support context related (or tacit) KT on health and safety.

There are studies on KT for OHS, however only few of them suggest in-depth evaluation of the approaches used (Dwayne 2019). Besides, those approaches are unique as they are tailored to particular context and audience. Further research is needed to understand the most efficient way of aligning KM and OHS systems in construction industry.

REFERENCES

- Aase, K, Nybø, G (2005) Organisational knowledge in high-risk industries: supplementing model-based learning approaches. "International Journal of Learning and Intellectual Capital", 12 (1), 49–65.
- Auch, F, Smyth, HJ (2010) The cultural heterogeneity of project firms and project teams, "International Journal of Managing Projects in Business", 3(3), 443-461.
- Argote, L, Ingram, P (2000) Knowledge transfer: A Basis for Competitive Advantage in Firms. "Organizational Behavior and Human Decision Processes", 82 (1), 150–169.
- APQC Best Practices Report (2013) Transferring and Applying Critical Knowledge, available at: <https://www.apqc.org/knowledge-base/documents/transferring-and-applying-critical-knowledge-best-practices-report> (accessed 31 November, 2018).
- APQC Review on Communities of Practice (2016) available at: <https://www.apqc.org/knowledge-base> (accessed 4 December, 2018).
- Bartsch, V, Ebers, M and Maurer, I (2013) Learning in project-based organisations: the role of project teams' social capital for overcoming barriers to learning. "International Journal of Project Management", 31(2), 239–251.

- Brady, T and Davies, A, (2004) Building project capabilities: from exploratory to exploitative learning, "Organization Studies", 25(9), 1601-1621.
- Bust, PD, Gibb, AGF and Pink, S (2008) Managing construction health and safety: migrant workers and communicating safety messages. "Safety Science", 46 (4), 585 – 602.
- Carrillo, PM, Ruikar, K, Fuller, P (2013) When will we learn? Improving lessons learned practice in construction. "International Journal of Project Management", 31(6), 567-578.
- Cox, SJ and Cheyne, AJT (2000) Assessing safety culture in offshore environments. "Safety Science" 34, 111-129.
- Crawford, JO, Davis, A, Walker, G, Cowie, H and Ritchie, P (2016) Evaluation of knowledge transfer for occupational safety and health in an organizational context: development of an evaluation framework, "Policy and Practice in Health and Safety", 14(1), 7-21.
- Dalkir, K (2005) "Knowledge Management in Theory and Practice". Oxford: Elsevier Butterworth-Heinemann.
- Davenport, TH and Prusak, L (1998) "Working Knowledge: How Organisations Manage What They Know". Cambridge MA: Harvard Business School Press.
- De Long, DW and Fahey, L (2000) Diagnosing Cultural Barriers to Knowledge Management. "The Academy of Management Executive", 14(4), 113-127.
- Denison, DR (1996) What is the difference between organisational culture and organisational climate? A natives point of view on a decade of paradigm wars. "Academy of Management review", 21(3), 619–654.
- Doytchev, D, Hibberd, RE, 2009 Organizational learning and safety in design: experiences from German industry. "Journal of Risk Research", 12, 295–312.
- Duryan, M and Smyth, HJ (2018) Cultivating sustainable communities of practice within hierarchical bureaucracies: the crucial role of an executive sponsorship. "International Journal of Managing Projects in Business", available at: <https://doi.org/10.1108/IJMPB-03-2018-0040>
- Dwayne, VE (2019) Knowledge transfer and exchange in health and safety: a rapid review, "Policy and Practice in Health and Safety", DOI: 10.1080/14773996.2018.1508116
- Eden, C and Ackermann, F (1998) "Making Strategy: The Journey of Strategic Management". London: Sage Publications.
- Eden, C (2004) Analyzing cognitive maps to help structure issues or problems, "European Journal of Operational Research", 159(3), 673–686.
- Edvinsson, L, Malone, MS (1997) Intellectual capital: realizing your company's true value by finding its hidden brainpower. New York, NY, USA: Harper Business.
- Gera, R (2012) Bridging the gap in knowledge transfer between academia and practitioners. "International Journal of Education Management", 26(3), 252-273.
- Grabher, G (2004) Learning in projects, remembering in networks? Communitarity, sociality, and connectivity in project ecologies. "European urban and regional studies", 11(2), 103-123.
- Health and Safety Commission (HSC) (1993) ACSNI Study Group on Human Factors. 3rd Report: Organising for Safety, London: HMSO.
- Health and Safety Executive (HSE) (2005) A Review of Safety Culture and Safety Climate Literature for the Development of the Safety Culture Inspection Toolkit, Sudbury: HSE Books.

- Health and Safety Executive (HSE) (2006) *Health and Safety in Construction*. London: HSE Books, Crown.
- Health and Safety Executive (HSE) (2018) *Construction statistics in Great Britain*. <http://www.hse.gov.uk/statistics/industry/construction.pdf>. Accessed 14 January 2019.
- Jashapara, A (2011) *"Knowledge Management: An Integrated Approach"*. 2nd Edition, Essex, UK: Prentice Hall.
- Kamara, JM, Anumba, CJ, Carrillo, PM and Bouchlaghem, N (2003) Conceptual Framework for Live Capture and Reuse of Project Knowledge. In: "Proceedings of the CIB W78's 20th International Conference on Information Technology for Construction", Auckland.
- Lave, J and Wenger, E (1991) *"Situated Learning: Legitimate Peripheral Participation"*, Cambridge: Cambridge University Press.
- Lee, T and Harrison, K (2000) Assessing safety culture in nuclear power stations. *"Safety Science"*, 34(1-3), 61-97.
- Lingard, H and Rowlinson, S (1997) Behavior-Based Safety Management in Hong Kong's Construction Industry. *"Journal of Safety Research"*, 28(4), 243-256.
- Miles, MB and Huberman, AM (2002) *"The Qualitative Researcher's Companion"*, Thousand Oaks, CA: Sage.
- Mueller, J (2015) Formal and informal practices of knowledge sharing between project teams and enacted cultural characteristics. *"Project Management Journal"*, 46(11), 53-68.
- Neal, A, Griffin, MA, & Hart, PM (2000) The impact of organizational climate on safety climate and individual behavior. *"Safety Science"*, 34(1-3), 99-109.
- Nesheim, T and Gressgård, LG (2014) Knowledge sharing in a complex organisation: Antecedents and safety effects. *"Safety Science"*, 62, 28-36.
- Nonaka, I (1991) The knowledge creating company. *"Harvard Business Review"*, 69, 96-104.
- Office for National Statistics (2018) *Construction statistics: Number 19, 2018 edition*. [.https://www.ons.gov.uk/businessindustryandtrade/constructionindustry/articles/constructionstatistics/number192018edition](https://www.ons.gov.uk/businessindustryandtrade/constructionindustry/articles/constructionstatistics/number192018edition). Accessed 19 January, 2019.
- Paulin, D and Suneson, K (2012) Knowledge transfer, knowledge sharing and knowledge barriers: three blurry terms in KM. *"The Electronic Journal of Knowledge Management"*, 10(1), 81-91.
- Podgórski, D. (2010). The Use of Tacit Knowledge in Occupational Safety and Health Management Systems, *International Journal of Occupational Safety and Ergonomics*, 16(3), pp. 283-310.
- Polanyi, M (1962) *"Personal Knowledge: Toward a Post Critical Philosophy"*. New York: Harper Torchbooks.
- Polanyi, M (1967) *"The Tacit Dimension"*. London: Routledge and Keoan Paul.
- Reason, J (1997) *"Managing the Risks of Organisational Accidents"*. Ashgate.
- Roberts, J (2000) From Know-how to Show-how? Questioning the Role of Information and Communication Technologies in Knowledge Transfer. *"Technology Analysis & Strategic Management"*, 12(4), 429-443.
- Senge, P (1990) *"The Fifth Discipline: The art and practice of the learning organisation"*, New York:Doubleday Business.
- Schein, E (2004) *"Organizational Culture and Leadership"*, San Francisco: Jossey-Bass

- Sherratt, F, Farrell, P and Noble, R (2013) UK construction site safety: discourses of enforcement and engagement, "Construction Management and Economics", 31(6), 623-635.
- Shereihiy, B, Karwowski, W (2006) Knowledge management for occupational safety, health, and ergonomics. "Human Factors and Ergonomics in Manufacturing", 16(3), 309-19.
- Smyth, H, Roberts, A, Duryan, M, Xu, J, Toli, M, Rowlinson, S and Sherratt, F (2019) Health & Safety and Knowledge Management in Construction. In: Proceedings of the "Association of Researchers in Construction Safety, Health, and Well-Being" (ARCOSH), 3 - 4 June, 2019, Cape Town.
- Szulanski, G (2000) The process of knowledge transfer: a diachronic analysis of stickiness, "Organizational Behavior and Human Decision Processes", 82(1), 9-27.
- Tangaraja, G, Rasdi, MR, Abu Samah, B & Ismail, M (2016) Knowledge sharing is knowledge transfer: a misconception in the literature. "Journal of Knowledge Management", 20 (4), 653-670.
- Törner M, Pousette, A (2009) Safety in construction – a comprehensive description of the characteristics of high safety standards in construction work, from the combined perspective of supervisors and experienced workers. "Journal of Safety Research", (40), 399-409.
- Vaught, C, Mallett, L, Brnich, Jr, MJ, Reinke, D, Kowalski-Trakofler, KM and Cole, HP (2006) Knowledge management and transfer for mine emergency response', "International Journal of Emergency Management", 3(2/3), 178-191.
- Wahlstrøm, B, 2011 Organisational learning – reflections from the nuclear industry. "Safety Science" 49(1), 65-74.
- Walker, A (2015) "Project Management in construction". London: John Wiley & Sons Ltd.
- Wamuziri, S (2011) Factors that contribute to positive and negative health and safety cultures in construction. "CIB W099 Conference. Prevention -Means to the End of Construction Injuries, Illnesses and Fatalities". Washington, DC, 24-26, August.
- Wiig, K (1997) Knowledge management: where did it come from and where will it go? "Expert Systems with Application", 13(1), pp. 1-14.
- Whittingham, RB (2004). "The Blame Machine. Why Human Error Causes Accidents". Oxford: Elsevier.
- Zohar, D (1980) Safety Climate in Industrial Organizations: Theoretical and Applied Implications. "Journal of Applied Psychology", 65(1), 96-102.