

HEALTH & SAFETY AND KNOWLEDGE MANAGEMENT IN CONSTRUCTION

Health and safety (H&S) statistics have plateaued in developed countries. H&S is frequently loosely coupled with project management. The challenge is to induce greater commitment to improve the role of contractors and subcontractors as systems integrators and providers respectively. Awareness creation and information sharing about H&S initiatives, near misses and incidents are prioritized at operational meetings at firm and project levels. This is supported by communication tools, including email alerts, Yammer and intranet sites, often grounded in a safety management systems (SMS). These systems are based in information processing. Converting information into applied knowledge requires a knowledge management system (KMS) and literature on KMS shows they are poorly developed in construction. Empirical evidence from main contractors and subcontractors collated in this research shows H&S is focused on information sharing rather than knowledge application. H&S is therefore disconnected from nascent KMS. The challenge from systems integration and solution provision is to align H&S SMS and KMS to reduce H&S incidents by systematically applying lessons learned and potentially linking to other areas, including wellbeing.

Keywords: Health and Safety (H&S), Information Processing, Knowledge Management Systems (KMS), Safety Management Systems (SMS), Systems Integration.

INTRODUCTION

Is occupational health, safety and wellbeing (OHSW) an integral part of the mindsets and systems of contracting organisations? In other words, is OHSW, and particularly health and safety (H&S), fully integrated into all other functions and operations? Is it, despite many improvements over successive years, especially in developed countries, still something of a "bolt on extra" in relation to operational activities?

A way of responding to these questions is to examine the extent to which OHSW and particularly H&S is integrated into formal and informal management systems. Main contractors act as systems integrators regarding the management and technical content that other construction organisations provide. The main contractor allocates resources to functions and operations at portfolio management, programme management and project management levels. Programme management interfaces with the project through systems involving for example information processing, knowledge management systems (KMS) and safety management systems (SMS). In practice, lessons learned at project level can be captured and transferred to the benefit other projects both for the firm and their clients through these systems.

Before now, research into OHSW, including H&S, has largely been addressed as a discrete topic, being considered separately from the broader systems of both main and subcontractors. The result has arguably been to position H&S as a "bolt on extra", despite its rise to become a top priority on a par with profit (Roberts et al, 2012). Yet the main contractor business model is failing and without investing to bridge the gap

between current service provision and growing client and societal demands they cannot maintain a relevant place in the market long-term (Smyth, 2018). Two key areas of investment to improve OHSW are safety management systems and knowledge management systems to engender a holistic approach to safety management and the application of lessons learned.

Prior research has demonstrated that there are weak H&S systems between the firm and project levels (e.g. Roberts et al., 2012; Smyth et al., 2019). However, this has not been addressed in detail. Thus, this paper does so, by focusing on two separate systems, safety management systems (SMS) and knowledge management systems (KMS). Conceptually, they are both valuable, transmitting information and converting it to knowledge for application on the ground. Therefore they both manage information and knowledge that is acquired from internal and external parties which has been developed experientially through prior operations. It could reasonably be expected that they are linked through an interface or integrated into a single system.

It is known that SMSs are variable in their rigor across construction organisations and that implementation is sometimes partial within any contractor (e.g. Tam et al., 2004; Park and Kim, 2013). The same applies to KMS (e.g. Anumba et al., 2005; Kelly et al., 2013). How far partiality stretches is a moot point, especially for KMS where analysis has been kept at a general level rather than drilling down to types of information and knowledge, such as specific bodies of technical expertise, sustainability, or H&S in particular.

Statistics for H&S have plateaued, especially in developed countries. Yet, the role of main contractors, who today largely perform the role of systems integrators rather than producers, should be driving forward improvement across a range of service fronts (e.g. Davies, et al., 2007; Deng and Smyth, 2014). Systems in construction have been found to be loosely coupled, which is important when projects do not have a memory per se (Dubois and Gadde, 2002). Integration implies tightening the coupling and capturing H&S project knowledge at the firm level for re-use. H&S, if addressed as a "bolt on extra", is effectually loosely coupled from the core of project and construction management, the challenge being to induce greater commitment to improving the systems integrator and provider roles of the main contractors and subcontractors respectively.

LITERATURE REVIEW

Safety management systems (SMS) represent a set of mechanisms to transfer information about near misses and accidents, as well as improved practice initiatives. Conceptually, SMS is part of the information processing approach to project management, whereby project and construction management bring together relevant information and critically address uncertainties to progress projects (Winch, 2010). Whether the information is taken up to affect future practice is partly a function of communication, but as such is happenstance, whereas an effective knowledge management system (KMS) requires engagement to translate information into application (e.g. Nonaka and Takeuchi, 1995). In construction, this requires engagement with systems at programme management level to take it from a singular project and potentially transfer into the context of other projects (e.g. Carrillo, 2004; Smyth, 2004) either through explicit knowledge transfer or an informal system, such as a community of practice (e.g. Wenger, 1998; Duryan and Smyth, 2018). An effective formal and/or informal system is important because otherwise knowledge becomes stuck in social and locational space (e.g. Szulanski 2000). It therefore has to

be communicated as information outside of the immediate project setting for its injection into other projects, which need to span rigid organisational boundaries (Dubois and Gadde, 2002; Gustavsson and Gohary, 2012) and with strong management support (Carrillo et al., 2013).

Designing a system with formal and informal governance mechanisms for project-related KMS is said to be complex for executives and senior management because of their financial preconceptions about minimizing investment and expenditure in competencies and capabilities (Foss, 2007; Pemsel and Müller, 2012). KMS is perceived to be about technical applications, rather than conducting operations safely, hence lack of prior conceptual and applied engagement between SMS and KMS to date. This is evidence of a lack of integration in theory and practice.

H&S has become an espoused top priority among practitioners (Roberts et al., 2012). Awareness creation has led to information sharing about H&S initiatives, near misses and accidents at operational meetings, use of email alerts, Yammer and other social media, videos and other mechanisms. Yet despite this, there is a failure to foster adequate mechanisms to induce the benefits of knowledge transfer as opposed to information sharing, so as to engender knowledge valuable to the business (Brown and Duguid, 2001).

It is now generally accepted that IT platforms are not the solution for effective KMS. Communication systems and IT programmes, such as Sharepoint®, only support, and do not induce, the culture for knowledge sharing and application (Bloom 2000; Smyth and Duryan, 2018). The notion that industries that are on a path towards maturity and H&S is itself following a linear path to maturity (e.g. Parker et al., 2006), has been challenged both in general and specifically for H&S in construction (Roberts et al., 2012). There appears to be a conceptual need to link SMS and KMS as part of improving H&S over and above the statistical plateau of H&S improvement reached in construction. This is also a service design function (e.g. Shostak, 1984; Zomerdijs and Voss, 2010) to address H&S in the organisation (Romme, 2003) and integrate it at firm and project level, including the interface between the two at programme management level. Service design extends beyond the immediate remit, yet becomes conceptually possible once SMS and KMS are integrated.

METHODOLOGY AND METHODS

An interpretative methodology is used (e.g. Denzin, 2002), which is appropriate for gauging perspectives on H&S, programme and operational systems. For communication, information processing and knowledge application. Interpretative methods do not force a theoretical approach, yet allows for prior theorisation to inform data collection and analysis. This suggests an inductive approach to build up the understanding of practice from the bottom-up (Eisenhardt, 1989). While theory development is not the aim, conceiving and examining H&S through the lens and interplay of KMS and SMS in theory and practice may induce theoretical insights.

The data collection process involved three stages. Some pilot interviews were conducted with key industry organisational actors in the UK. This informed a workshop with these and other organisational representatives. This was a type of engaged research (Van de Ven, 2007) that was used to generate questions employed in the third stage, the main interviews.

Interviews were conducted with five types of organisation: institutional, clients, main contractors, subcontractors and self-employed operatives. They were conducted with

Table 1. Schedule of Organisations and Interviews

Type of Organisation	Organisation	Interviewee Role	Subtotals	Total	
Institutional	Industry Standards	Health and Safety Principal Inspector	1		
		Health and Safety Inspector	1		
	Government & Former Professional Body	Industry Expert and Chair of Professional Body	1	3	
Clients	Infrastructure	Head of Commercial	1		
		Senior Procurement Manager	1		
		Occupational Health & Wellbeing	1		
		H&S Manager	1		
		Change Programme Manager	1		
	Developer	Head of H&S	1		
		H&S Manager	1		
		Director	1	8	
Main Contractors	International Contractor	Divisional Managing	1		
		Construction Director	1		
		Associate Director Health and Wellbeing	1		
		Health, Safety and Wellbeing Manager	1		
	International Contractor	SHEQ	1		
		H&S Director	2		
	International Contractor	Chief Executive Officer	1		
		Quality Improvement Manager	1		
		H&S, Quality and Environment Manager	1		
		HR Manager	1		
		Pre-Construction Director	1		
		Operatives	3	15	
	Subcontractors	M&E	HSEQ/Improvement Manager	1	
			HSEQ Advisor	1	
			Electrical Project Engineer	1	
Technical Services			1		
Site Engineer			1		
Apprentice			1		
Structural Steel		Group HSE	1		
		H&S/Environment Director	1		
		Commercial Director	1		
		Assoc. Commercial Director	1		
		Operations Director	1		
		H&S Advisor	1	12	
Sub-subcontractors	Control Systems	Operative	1		
	Plumbing	Supervisor	1	2	
Other Contractors	-	Site Manager	3		
		Project Manager	1	2	
Self-employed	Ventilation	Supervisor	1	1	
Interviewee Total			43		

senior management, head office and site management and operatives. They included those responsible for OHSW, but also those in other roles and functions who would be expected to engage with OHSW directly or indirectly if it is part of an integrated approach. Table 1 shows the schedule of interviews. A total of 43 interviews were conducted. From the table it can be seen that 14 were site based, and 17 were representing tier 3 and below in the supply chain, rendering this study unusual to reach beyond the first and second supply chain tiers.

FINDINGS AND ANALYSIS

The analysis commences at the strategic level of the firm. Asked about the business model for their firms, respondents referred to the Acts and Regulations, hence legislation and compliance on the one hand, and to H&S being a top priority and embedded in everything the firms do on the other hand (e.g. Head of Commercial, Infrastructure Client; Industry Expert and Chair of a Professional Body). However, on further examination, while H&S is addressed at all operational meetings, it became clear that it is not integrated into any business model among contractors, or to the extent that it is present, the focus was on information dissemination as part of diligent management practices of compliance.

Cascading to the operational level in the firm and onto sites, H&S practices, near misses and accidents were part of information processing. It worked in parallel with behavioural programmes and procedural initiatives for H&S, as well as standard practices such as induction and toolbox talks. This also worked alongside dissemination of information, for example through safety bulletins, email alerts and social media applications (e.g. QHSE Advisor, International Subcontractor; HR Manager, International Contractor). The flow of information from the project level to the firm and the flow of initiatives to the operational level forms part of the safety management system (SMS) for firms.

Firms, largely due to legal and regulatory compliance, particularly flowing from corporate manslaughter legislation in the UK, have developed reasonably robust SMSs. They are largely based upon information processing, that is the collection of data and dissemination. There is a robust process of awareness creation and informed procedures from prequalification, through tendering to site execution. Because it stresses firms demonstrating responsible compliance, the processes emphasise communication and awareness creation rather than the conversion of information into learning and applicable knowledge. Even where initiatives are formatted into useable knowledge, for example the creation of videos, little attention is given to how recipients use such knowledge. For example, many of the operatives interviewed reported that main office staff and some site management staff, who have management and project management degrees, cannot understand how many tasks can be practically and safely undertaken in different and changing contexts (cf. Sherratt, 2016). It was also commonplace that there was either a lack of awareness of the material or inability to access it during construction work. For example, one major international subcontractor produced a series of H&S videos for training, yet operatives were not only unaware of them as they had not been shown them at induction or toolbox meetings on site, and even had they been aware of them, they could not have accessed them due to restrictions on the use of tablets and smart phones on site, except in limited designated areas. Managers stated that to the extent that initiatives reach into operations, their impact is hard to measure (e.g. Health and Safety Manager, Infrastructure Client).

Most initiatives were top-down. However, one international contractor has adopted bottom-up initiatives. Quarterly review meetings for sharing knowledge among business units involves managers across projects and those in head office (Health & Safety, Quality & Environment Manager, International Contractor). At operative level there are daily site meetings for information sharing, and younger professionals work alongside experienced direct employees as a learning by doing initiative. However, operatives on sites are less informed about learning than managers in the offices (Operative, International Contractor). In one international subcontractor, operatives were consulted in compiling some methods statements and videos of site activity were found to be useful in the context of generating methods statements (Health and Safety Advisor).

Awareness is developed through operations management training. For example in one firm, key staff and project managers were reported as undertaking training to address H&S (H&S Director, International Contractor). It is left to individuals to internalise the information provided as knowledge, which in the same firm proved challenging for some staff during a recent period of rapid recruitment (Smyth, Roberts, Razmdoost, 2019).

Firms have basic infrastructure and typically a semblance of knowledge management systems (KMSs) for capturing and sharing lessons learned on and between projects, especially in the larger organisations. Systems were reported as being most effective across firms at the project front-end for injecting lessons learned (Industry Expert and Chair of a Professional Body; Group Business HSEQ/Improvement Manager, International Subcontractor).

On the client side, a developer reported they use KMS internally, for example disseminating through Yammer, and for their supply chain through websites to share knowledge and information. If a supplier has an incident on site they come and share it in the group (Group Head of Health and Safety, Developer Client). Another client interviewee made an example of how learning and knowledge sharing across projects enabled them to quickly react to a serious injury (Head of Commercial, Infrastructure Client). However, this is largely information sharing rather than knowledge generation, no matter how well and frequently information is cascaded in the organisation and supply chain (e.g. Health and Safety Manager, Infrastructure Client). Further, some clients have multiple document and intranet channels that deny coordinated learning and application (e.g. Occupational Health & Well-being Manager, Infrastructure Client), which was reported as a “broken” process (Change Manager, Infrastructure Client).

Among the contractors and subcontractors, there are typically intranet systems and human systems, especially for project debriefing. Therefore, capturing and sharing knowledge largely relies upon explicit knowledge and formal systems where application is across and between projects. However, engagement with these systems appeared to be minimal and that there was a lack of leadership commitment, hence support. Drawing on recent research in support, part of this is thought to be the absence of cross-functional working, such as human resource policies around knowledge management about staff selection, promotion and annual review criteria. Having non-project budgets at programme level to capture project knowledge in a timely way also absent (e.g. Duryan and Smyth, 2019). IT platforms, such as Workspace® software, are used yet input levels and usage are low (Associate

Commercial Director, International Subcontractor). Therefore, there was a lack of information being fed into KMS and in a timely way.

This is exacerbated by the absence of bottom-up learning. Several operatives said they not only knew less about initiatives and procedures developed top-down (e.g. Operative, International Contractor), they were not asked to contribute. Operatives emphasised the point that they know how to undertake tasks safely in different contexts with experience, but that is not understood by those who are office based and educated in management (Mechanical Site Engineer, International Subcontractor), a point echoed by some management (Operations Director, International Subcontractor; Associate Commercial Director, International Subcontractor; Technical Services Manager, International Subcontractor). Indeed, operatives were forced to ignore some guidance to complete some tasks due to its perceived contextual irrelevance (Site Supervisor, Self-employed). Resolving and learning from these H&S practices requires more bottom-up engagement.

SMS was developed to reasonably strong levels of having information availability and it being processed at programme management level for dissemination, yet a lack of a system to translate it into useable knowledge, while KMS had strengths in albeit partial yet emergent systems. SMS and KMS were disconnected, having a twofold consequence. First, it is evident that H&S is still something of a "bolt on extra", for while it is handled at high level meetings as a top priority issue, it is separated out from other mainstream operational issues around activities, tasks, time and cost management. Second, there is an opportunity to marry the two systems to not only induce integration, but to develop systematic capabilities the management of information, knowledge and learning across all activities, including OHSW, and especially H&S on site. As many of the mechanisms are partially in place, low investment is needed to transform these into an effective combined system to improve performance. It is arguably only through undertaking this type of integration and capability development that firms are going to transform site operations (cf. Brady and Davies, 2004). In this case, it is a means to improve upon the H&S statistics that have currently plateaued. More fundamentally, it is the only way to transform the firms, especially main contractors with their broken business models (Smyth, 2018). Business models based on albeit incremental investment to yield a return point the way forward, whereas traditional models based upon cashflow management and return on capital employed no longer work. H&S as a top priority in particular and OHSW in general can and arguably should be positioned as central elements of evolving business models in construction.

There were also several areas into which neither SMS nor KMS extended and represent wellbeing issues with H&S consequences:

1. Fatigue on site, where directly employed operatives are encouraged to work long hours, which emanates from and is supported by culture of stressful working among management staff in all contractors. Wellbeing measures on site can have the perverse effect of encouraging long hours, extensive remote working and travel to work.
2. Fatigue on site, where contract staff are incentivised to work long hours and are frequently poorly monitored, for which the main contractors and large subcontractors take scant responsibility in general and specifically regarding fatigue.
3. Communication and learning among ethnic groups, where a wide variation of understanding and learning exists from induction and toolbox talks to reading site signage.

CONCLUSION

Empirical evidence from main contractors and subcontractors reported in this study shows occupational health, safety and wellbeing (OHSW), and particularly health and safety (H&S), is largely focused upon information sharing by employing a safety management system (SMS). Knowledge management systems (KMS) are partially developed, but to the extent they are present, they are disconnected from SMS.

In summary, firms, largely due to compliance issues, have developed reasonably robust SMS. They are largely based upon information processing (cf. Winch, 2010), that is the collection of data and dissemination. Information is typically not being converted into applicable knowledge and learning. Even where initiatives are formatted into useable knowledge, for example the creation of demonstration videos, there was either a lack of awareness of the material or inability to access it during construction work due to procedures around when and where tablets and smart phones can be used on site.

Firms have basic infrastructure and typically a semblance of systems for capturing and sharing lessons learned on and between projects. Between projects, capturing and sharing largely relies upon explicit knowledge and formal systems. However, engagement appeared to be low, confirming prior research concerning the lack of leadership support, human resource policies and non-project budgets at programme level (e.g. Duryan and Smyth, 2019). There were also different views in the same organisation about knowledge sharing. Lack of clarity reduces engagement and relevance of the (formal and informal) systems. Therefore, there was an absence of information being fed into the KMS, and when it was it tended not to be done so in a timely way.

Therefore, SMS had strengths concerning availability of information, while KMS had strengths in nascent and emergent knowledge systems. Yet SMS and KMS were not linked. This has a twofold consequence. First, it is evident that H&S is still something of a "bolt on extra", for while it is handled at high level meetings as a top priority issue, it is separated out from other mainstream operational issues around activities, tasks, time and cost management. Second, there is an opportunity to marry the two systems to not only induce integration, but to develop systematic capabilities to manage information, knowledge and learning across all activities, including OHSW, and especially H&S on site. As many of the mechanisms are partially in place (cf. Anumba et al, 2005), low investment is needed to transform these into an effective combined system to improve performance. It is only undertaking this type integration and capability development that firms are going to transform and thus in the case of H&S improve statistics that are currently plateaued. What is the incentive to do so? The current contractor business model is broken and survival is threatened, especially among main contractors. Business models based on incremental investment to yield a return have become the required trajectory (Smyth, 2018). H&S as a top priority in particular, and OHSW in general, can and arguably should be positioned as central elements of evolving business models in construction.

The challenge for practice, therefore, is to align SMS with KMS, and in so doing, enhance the functioning of each to improve general performance and specifically reduce H&S risks, incidents and accidents by systematically applying lessons learned from both top-down and bottom-up learning. There are wider benefits from enhancing

cross-functional coordination and improving wellbeing in construction through a more holistic and integrated approach.

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