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Design for Occupational Safety and Health: A Theoretical Framework for Organisational Capability

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Abstract

For several decades, scholars and practitioners have searched for the underlying causes of OSH incidents on construction projects. One of the insights from the investigations is the fact that the seeds of accidents, fatalities and occupational related ill-health are sown across various design and procurement decisions made during the pre-construction stage of project development. This insight has given rise to the design for occupational safety and health (DfOSH) initiative which has even informed regulations in certain countries, particularly the UK. However, knowledge and understanding of what, specifically, constitutes the organisational capability of design firms of generating designs which are inherently safe is very limited. Hence, this study undertakes a systematic review of prior conceptualisations of organisational capability, carries out contents analyses of the conceptualisations and provides a robust conceptualisation of the construct. The robust conceptualisation underpins the development of a nomological network to operationalise the construct organisational capability in respect of design firms' ability to ensure design for occupational safety and health (DfOSH). Organisational capability is presented as a multi-dimensional construct that can be operationalised at various levels of specificity. The proposed framework can support the identification of organisational capability gaps that design firms seeking to build their DfOSH capability can address while at the same time assisting project clients to clarify the organisational capability of design firms in the procurement process.

Keywords: Design, construction, occupational safety and health; prevention through design; organisational capability; theoretical framework.

1. Introduction

The construction industry is considered one of the highest contributors to work-related accidents and ill-health in most economies around the world (Hadikusumo and Rowlinson, 2002; Sousa, et al., 2014; Yuan et al., 2018). For example, in the UK, the construction industry accounted for 30% of work-related fatalities in the 2018/2019 reporting year (HSE, 2019a). Statistics from HSE (2019b) indicate that, annually, about 3% of UK construction industry workforce suffers from occupation-related illness while about another 2% becomes victims of work-related injuries. This undesirable phenomenon has set both practitioners and scholars, over some decades now, searching for the underlying causes of poor occupational safety and health (OSH) performance on construction projects. In this search, it has been revealed that the seeds of accidents, fatalities and occupational related ill-health are sown during the design stage of the project development process (Szymberski, 1997; Williams, 1998; Gibb et al., 2004; Gambatese et al. 2005; Behm, 2005; Toole, 2007; Cooke et al., 2008; Lingard et al., 2015; Manu et al., 2019). Several studies (see for example Gambatese et al., 2005; López-Arquillos et al., 2015; Goh and Chua, 2016) have made calls for awareness creation and capacity building among designers to enhance their contributions to effective management of OSH on projects, particularly at the pre-construction stage. This call is, primarily, informed by the design for occupational safety and health (DfOSH) initiative.

The influence of design decisions and other pre-construction procurement decisions on downstream accidents and ill-health came to the attention of the European Union and the European Council responded by adopting Council Directive 1992/57/EEC on the implementation of minimum safety and health requirements at temporary or mobile construction sites. This Directive requires the appointment of two types of coordinators for safety and health matters on construction projects that will require more than one contractor on the construction site. Referred to in this paper as the Pre-Construction Phase Coordinator (PCPC), the first type is to take responsibility for coordination during the design and project preparation stage of projects. The second type of coordinator is referred to as the Construction Phase Coordinator (CPC) and must be engaged for coordination of OSH matters during the construction phase of projects. Having a national law providing for the appointment of these two dutyholders on projects is a mandatory requirement of Member States although no details are prescribed for the roles (for example, the type of professional to exercise it and whether the two roles may be performed by the same entity). In 1994 the UK, which had been a full member of the EU until recently, transposed the Directive into UK legislation as part of the Construction (Design and Management) Regulations 1994 (CDM 1994). These Regulations imposed statutory health and safety duties on the traditional members of construction project stakeholders: clients, designers and contractors. They also created the dutyholders of “Planning Supervisor” and “Principal Contractor” with defined statutory duties to take on the performance of the roles of the PCPC and CPC, respectively, under the EU Directive.

The UK's Health and Safety Executive (HSE), the national regulatory authority for health and safety, has had to respond twice to concerns about pre-construction coordination health and safety matters, attempting to change the role for this each time. About ten years after the CDM 1994 came into force, they were replaced with the Construction (Design and Management) Regulations 2007 (CDM 2007) which changed the label for the pre-construction coordinator from "Planning Supervisor" to "CDM Coordinator". The CDM 2007 required clients to appoint individuals or organisations with individual competence and corporate competence, respectively, in the design and management of construction projects. However, one of the unintended consequences of the regulatory prescription of *competence* and its assessment in an approved code of practice (ACOP) was the proliferation of third party assessment schemes that were uncoordinated, bureaucratic and costly to organisations, particularly the smaller ones (HSE, 2014). CDM 2007 was in turn replaced about eight years later with the Construction (Design and Management) 2015 Regulations (CDM 2015). The key changes made in CDM 2015 are: (a) putting much greater emphasis on the coordination of the pre-construction design process and replacing "CDM Coordinator" with "Principal Designer" (PD); (b) replacement of the requirement for competences of dutyholders with skills, knowledge and experience (SKE) of individual dutyholders and "organisational capability" where a dutyholder is an organisation.

The Principal Designer, according to the current Regulations, is appointed by the client at the early stage of the project development process to plan, manage and monitor the pre-construction phase and coordinate matters relating to health and safety during the pre-construction phase to ensure that, so far as is reasonable practicable, the project is carried out without risks to health or safety. Again, in the replacement of the CDM 2007 with CDM 2015, the HSE has indicated that the health and safety *competence* should be addressed by professional bodies and the industry rather than by a regulatory requirement (HSE, 2014). Thus, the current view of HSE and CDM on assigning DfOSH competence of designers to professional bodies justifies an investigation into what, specifically, constitutes SKE for the individual designer and organisational capability for the corporate designer and how they can be assessed. This study particularly focuses on the explication and operationalisation of organisational capability for DfOSH as it relates to design firms. It is expected that this will spawn further studies on SKE as they relate to individual designers.

Paragraph 8 of the CDM 2015 puts on anyone appointing a corporate CDM dutyholder, including a design firm, a duty to take reasonable steps to satisfy itself that the appointee has the organisational capability to carry out the work in a way that secures health and safety. Correspondingly, a design firm must not accept an appointment unless it has the corporate capability to carry out the assignment in way that secures health and safety. Failure to fulfil these duties is a criminal offence for which the appointer and the appointee may be prosecuted. Assessment and measures of organisational capability are therefore of paramount importance. One of the most recent studies to investigate the organisational capability for DfOSH was conducted by Manu et al. (2019). Their study employed a combined approach of focused group discussion (FGD), a Delphi technique and voting analytic hierarchy process (VAHP) to empirically ascertain the elements of organisational capability of design firms in respect of DfOSH. The study above provides a useful empirical basis to understand the organisational capability construct with regard to DfOSH.

The study from which this paper is developed takes an alternative approach based on the wide recognition in the research literature (Collins and Stockton, 2018; Rule and John, 2015) that a theoretical framework of a construct is not only an essential precursor of its assessment and measurement but also a necessary underpinning for the development of knowledge about it. Further, prior studies on organisational capability of design firms in respect of DfOSH do not indicate any clear levels of performance at which the organisational capability of design firms can be expected and measured. Considering the above, this study seeks to advance knowledge in this area and contribute to the literature in several ways. First, the study makes a contribution by explicating or providing a conceptual understanding of the organisational capability construct. Second, it provides an integrated framework for the assessment and measurement of the organisational capability of design firms in respect of DfOSH. An important part of this integrated framework is the ability to indicate the alternative levels of performance at which organisational capability of design firms can be expected or measured.

The paper is structured in eight sections. The first section introduces the study. In the second section, an overview is provided for the OSH concept. A literature review of the DfOSH initiative in construction is presented in the third section. The method or approach to the study is indicated in the fourth section. The fifth section focuses on the meaning of the organisational capability construct. In the sixth section, the theoretical integrated framework for assessing and measuring organisational capability of design firms is presented. The seventh section offers some discussions on the framework with pointers for further research. The conclusions of the study are offered in the final section.

2. The concept of occupational safety and health (OSH)

OSH is a concern in all countries of the world and across all economic sectors. Hence, it is susceptible to a wide range of conceptualisations. A proper and a general understanding of OSH is therefore required to ensure its effective management. The International Labour Organisation (ILO) (2011) defines OSH as a discipline dealing with the prevention of work-related injuries and diseases including the protection and promotion of the health of workers. Similarly, Luczak et al. (2000) conceive OSH as the elimination of hazardous conditions and the promotion of health in the context of occupation. Generally, how OSH is defined and understood may vary across sectors and cultures. However, OSH primarily targets the improvement of the working conditions and environment of workers. This goal is normally pursued in Alli (2008)'s definition of OSH as the science of anticipation, recognition, evaluation and control of hazards arising in or from workplace that could impair the health and well-being of workers while also considering the possible impact on the surrounding communities and the general environment.

Alli (2008)'s conceptualization of OSH does not only indicate a clear and a systematic approach to managing OSH in the context of occupation but also elicit an important view. The notion of hazards arising in or from the workplace has both present and forward dimensions. Every work type, that follows a process, leads to an output or product (Germain et al. 2001). Hence, the prevention of hazardous conditions and the promotion of the health of workers during the process represent the present look. Again, it is expected that the output, or the product which arises from the process, also continues to maintain the capability of prevention of hazardous conditions as well as the promotion of health and that represents the forward look.

The construction industry, like other industries such as aircraft and automobile manufacturing, deals with products that do not only provide and influence the environments of several people but also provide further work for those who need to maintain the products after they have been built. Hence, in understanding OSH as it relates to construction, the scope or emphasis should not only be on hazards arising in the workplace (the process) but also attention should be paid to hazards arising from the work (product). Such an understanding will put OSH risk in its proper perspective, especially on construction projects, and ensure it effective management.

3. Overview of the design for occupational safety and health (DfOSH) concept in construction

OSH risk on construction projects has been a thorny issue in the industry for some time now. This has spawned a number of studies, for some decades now, as to how to address the challenge of OSH risk albeit with nebulous results. Findings from prior studies on OSH risk management in the construction industry seem to point to a new thinking of addressing OSH risks at source (Szymberski, 1997; Williams, 1998; Gibb et al., 2004; Gambatese et al. 2005; Behm, 2005; Toole, 2007; Cooke et al., 2008; Lingard et al., 2015; Manu et al., 2019). In other words, the task of managing OSH risks should be assigned to stakeholders of the industry who generate those risks as they have the most opportunity to manage them (Gambatese, 2008; Rajendran and Gambatese, 2009; HSE, 2015). This notion has informed a new research agenda in the area of Design for Occupational Health and Safety" (DfOSH) [also referred to as "Design for Safety" (DfS), "Prevention through Design" (PtD), "Safety in Design" (SiD), "Construction Hazard Prevention through Design" (CHPtD), "Safe Design" (SD)], all in an attempt to effectively deal with the challenge of OSH risks on construction projects. Traditionally, the responsibility for managing OSH risks had been left with main contractors, especially at the project implementation or construction phase of projects (Hare et al., 2006). However, this new way of managing OSH risks advocates for a shared responsibility among project stakeholders.

The Australian Safety and Compensation Council (2006) defines DfOSH as a process of "the integration of hazard identification and risk assessment methods early in the design process to eliminate or minimise the risks of injury throughout the life of the product being designed." This definition corroborates and extends an earlier understanding provided by Gambatese et al. (2005) who indicated that "designing for construction safety entails addressing the safety of construction workers in the design features of a project". Proactiveness is the bedrock of risk management and this equally underpins the DfOSH concept. Hence, Cooke et al (2008) argue that the failure to address health and safety in construction designs is at odds with contemporary thinking in risk management, where the most opportune time for dealing with hazards is their elimination or minimisation at source. Generally, when designers make decisions on construction products, they are influencing the material choices, the sizes and positions of project features as well as the construction methods which can significantly impact the safety and health of individuals who build, occupy, maintain and eventually demolish those construction products (Hinze and Gambatese, 1994; ECI, 1996). This suggests that effective OSH risk management on construction projects must emanate from the project source. Figure 1 indicates the place or region of influence of DfOSH in the construction project development process. Generally, on most projects, as a result of speed required by clients, designs (particularly specialist engineering ones) can still progress deep into the construction phase of the project development process. However, the most opportunity to influence the project OSH outcomes – downstream of the construction supply chain – through design is presented at the pre-construction phase.

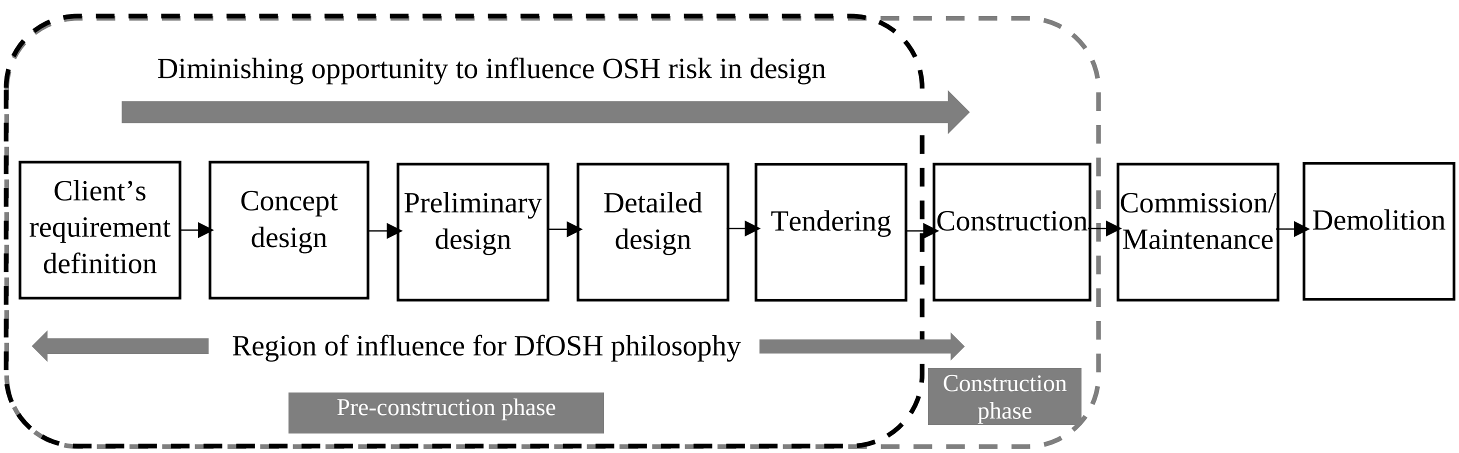

Figure 1: Region of influence for DfOSH philosophy in the project development process

Many studies (for example, Szymberski, 1997; Williams, 1998; Gibb et al., 2004; Gambatese et al. 2005; Behm, 2005; Toole, 2007; Cooke et al., 2008; Lingard et al., 2015; Bong et al., 2015; Goh and Chua, 2016; Poghosyan et al., 2018) have investigated the connection between design and accidents in the construction industry. For instance, in Australia, Driscoll et al. (2008) reported 44 percent of construction fatalities to be design-related. In the UK, an investigation of 100 nonfatal accidents in the construction industry indicted design as a contributing factor in about 50 percent of the cases (HSE, 2003). Behm (2005) undertook a review of 224 construction fatalities in the USA and realised that in 94 of the cases (representing 42 percent), the fatalities could be linked to the design. In the construction industry, the assertion that the opportunities to eliminate or minimise OSH risks are highest at the beginning of a project and diminishes as the project development phases progress is often cited in literature (Szymbersky, 1997; Toole, 2007).

Under the concept of DfOSH, the call for all key stakeholders in the construction industry (particularly, clients, architects, engineers and contractors) to take collective responsibility to minimise OSH risks to construction workers, maintenance workers, users of the construction product as well as the demolition workers is an important one (Goh and Chua, 2016), particularly at the upstream stage of the construction supply chain. However, there are a number of barriers to effective implementation of this concept in practice and these have often been articulated in literature. For example, in the USA, Gambatese et al. (2005) indicated that the lack of consideration for DfOSH was largely due to designer mindset towards safety and lack of knowledge among designers. In the UK, Larsen and Whyte (2013) realised that after about two decades of regulation [under the Construction (Design and Management) (CDM) Regulations (1994, 2007)] to ensure DfOSH in the construction industry, there were still challenges in getting buy-in from designers as “safety is very much seen as an afterthought or bolt-on to the design”.

Other studies (López-Arquillos et al., 2015; Goh and Chua, 2016) have also highlighted the lack of emphasis on DfOSH in the training of designers in tertiary institutions. Weak support from clients is also pointed out as one of the barriers to effective implementation of DfOSH (Oney-Yazici and Dulaimi, 2014; Hwang et al., 2014). In a study conducted by Goh and Chua (2016) in Singapore, about 70 percent of 43 civil and structural engineers surveyed felt that the client and end-users provide the greatest motivation for undertaking DfOSH in the construction industry. This brings to the fore, the role of clients in enabling or constraining the practice of DfOSH on construction projects. This has been recently re-emphasised by Poghosyan et al. (2018). Further, even if training and motivation were in place, we still lack a uniform and standardised framework for DfOSH capability.

Many studies in the extant literature have considered different aspects of DfOSH in an attempt to enhance its implementation and broaden the body of knowledge in this area. For example, Behm et al. (2014) carried out a study on developing DfOSH thinking among undergraduate engineering students. Their study developed and implemented a DfOSH education intervention with engineering students and measured the change in knowledge and comprehension of DfOSH principles among the students at the end of their programme. The study found out that the students' thinking in respect of DfOSH developed and changed regarding their design responsibilities. Further, Hallowell and Hansen (2016) conducted a study that sought to ascertain the extent that construction hazards are recognizable by designers during designs as well as identifying approaches to improve the hazard recognition skills of designers. Their study employed a multi-phase experiment that identified 12 representative construction modules. 17 designers observed these modules; subsequently an interview was conducted to ascertain their recognition of hazards present. Their study found out that the average designer's hazard recognition skill was 51%. Again, the study revealed that the hazard recognition skill of designers with construction experience, was on the average, 45% higher than designers with no construction field experience. Still on the training of designers regarding the DfOSH concept, Din and Gibson (2019) embarked on a study that sought to explore the most effective approach to getting students to accept DfOSH thinking. Their study developed three approaches (a computer-based serious game, a paper-based game [the paper version of the computer game] and a traditional lecture), implemented them and measured their pedagogical value on students. The computer-based serious game was found to be more effective as compared to the lecture. The paper-based game failed to motivate students to learn DfOSH thinking.

On the aspect of regulations, Aires et al. (2010) studied the effect of the European Directives on construction workplace accidents as a result of DfOSH. Their study first analysed policies regarding accident prevention in the European Union, as initially stipulated in the European Framework Directive 89/391/EEC, and more specifically in Directive 92/57/EEC, on the implementation of minimum safety and health requirements at temporary or mobile construction sites. Subsequently, the study analysed the incidence rate of workplace injuries and fatalities in the construction sector in each country from the year when these regulations came into force until the time of study. The study realised that, although these regulations were not the only factor to be considered, evidence indicates that, since the regulations came into force, the outlook in the European countries is positive and the incidence rate has decreased. In an attempt to streamline the DfOSH research agenda, Hardison and Hallowell (2019) in their recent study conducted a review of the DfOSH research to provide perspectives, evidence and future objective research agenda. The study found out that no objective evidence exists to validate the actual risk reduction over the project lifecycle as a result of the DfOSH concept. Again, their study recommends that future objective research should: consider understanding hazard recognition during design using available documentation and technological platforms, and experimentally test the efficacy of DfOSH tool and lifecycle safety risk assessments of proposed DfOSH solutions.

The study by Poghosyan et al. (2020) is the most relevant to the scope of this study. Drawing on the capability maturity concept combined with the application of expert group techniques, their study developed a maturity model that enables design firms to assess their DfOSH capability. Their model captured 18 DfOSH organisational capability attributes through expert group techniques. These were subsequently mapped onto five stages of capability maturation. However, there has been no study in the DfOSH area particularly aimed at explicating or conceptualising the organisational capability construct as it relates to DfOSH as a basis for its meaningful operationsalisation. Further, the DfOSH capability maturity model by Poghosyan et al. (2020) considers the DfOSH capability of design firms at the project level. The challenges facing clients and business, nowadays, are getting complex which requires multiple projects, and not a single project, to be delivered to address them. This takes the DfOSH capability requirement of design firms beyond the level of projects to programmes and possibly portfolios. This study, thus, provides a theoretical framework that considers the DfOSH capability of design firms as a multi-dimensional construct that can be operationalised from a task to a portfolio level.

4. Method

This study initially conceptualises the organisational capability construct, as it related to firms with responsibility to DfOSH, and subsequently develops an integrated framework for the operationalisation of the construct. To fulfil the first part, a review of literature of how prior studies have sought to conceptualise organisational capability was undertaken. This was to provide a basis for a conceptual content analysis, synthesis and provision of broad and comprehensive conceptualisation of the construct. Scopus was used as the main database for the literature search with additional information from Google Scholar. In comparison with other databases (e.g. PubMed, Web of Science and Google Scholar), Scopus has an extensive coverage in all fields including science, technology, social sciences, arts and humanities (Chadegani et al., 2013; Mongeon and Paul-Hus, 2016). The key search words or phrases were "Organisational capability" AND "Design" and the search returned a total result of 456. Conference papers and grey literature sources were excluded in the literature search, after Hardison and Hallowell (2019), for two reasons: (a) the peer-review processes and standards for publication are highly variable and difficult to measure with those sources (b) the inclusion of only journal articles provides a quality standard and appropriate scope for this search. After the application of the exclusion criteria indicated above, the total result was reduced to 335. The search results covered over 15 subject areas such as business, management and accounting; engineering; social sciences; arts and humanities; decision sciences; economics and finance; medicine; psychology; computer science; etc. The year range for the literature search was from 1981 – 2020, as offered by Scopus. Only literature in English were considered.

The identified publications were screened, preliminarily, by checking the abstracts to establish their usefulness to the review. The screened publications were subsequently assessed for eligibility. The main criterion for eligibility was that the publication must clearly provide or indicate a definition for the organisational capability construct. Out of the 335 publications screened, preliminarily, 128 were passed unto the eligibility stage, and 207 publications were excluded for their lack of relevance to the review. Next, 113 publications were excluded from the conceptual analysis and synthesis, as they did not provide or indicate any specific definitions for the construct – organisational capability. Additionally, the reference sections of the publications that provided specific definitions of the construct were specifically analysed to locate further relevant publications from Google Scholar in a second search. This second search added 7 more publications to the existing 15 publications from Scopus. In total, 22 publications were finally considered for the conceptual content analysis and synthesis of the organisational capability construct. Figure 2 indicates the publication selection process adapted from Moher et al. (2009) PRISMA systematic literature review process.

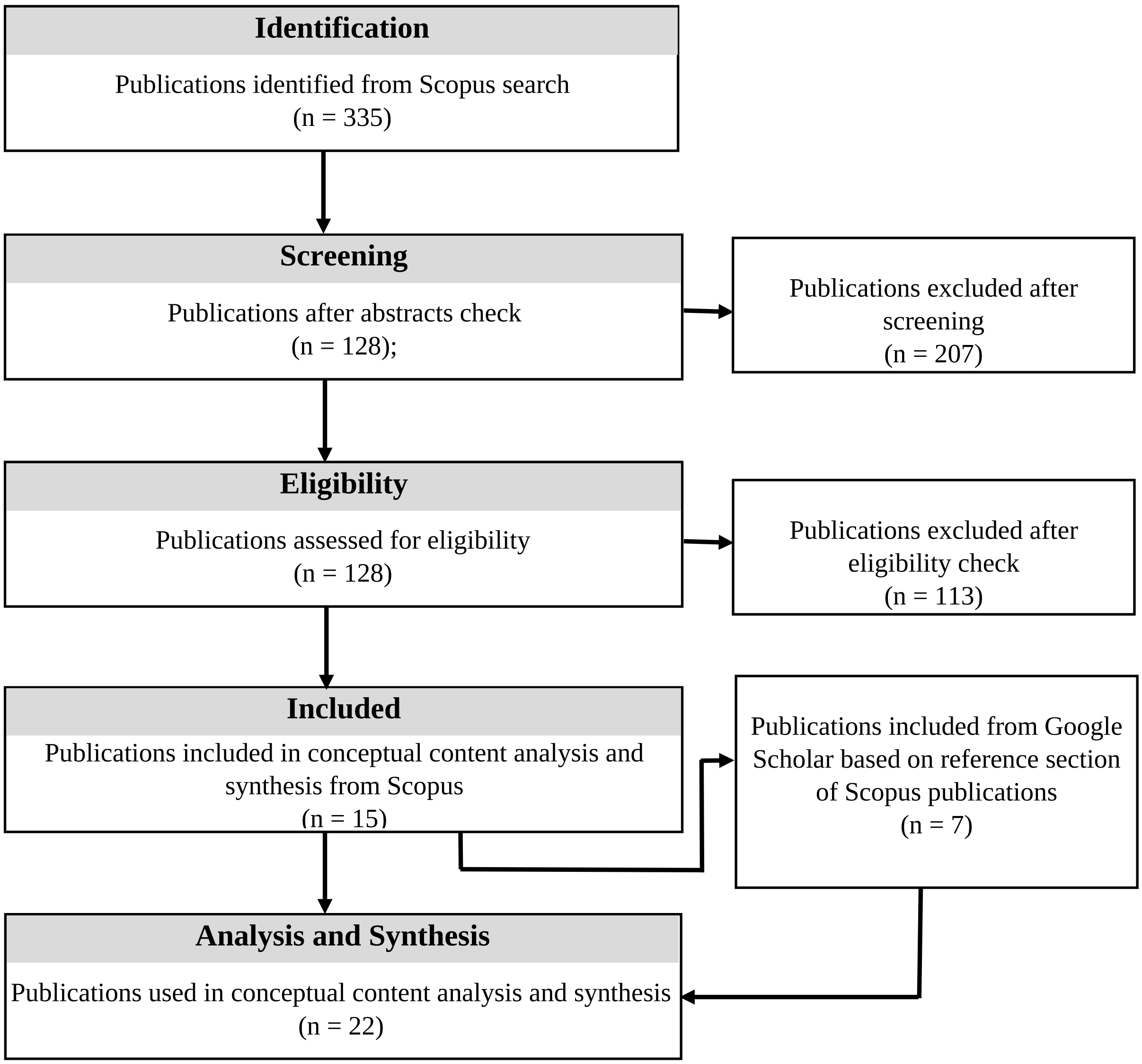

Figure 1: Publication selection process adapted from Moher et al. (2009)

The conceptualisation of the organisational capability construct in the first part of the research approach provided a basis for identifying the common components that explicate the construct from the perspective of prior studies. Components that were suggested in at least about 30% of the total number of studies that conceptualised organisational capability were deemed important in explicating the construct as indicated in the Appendix. The 30% criterion is specific to this study as a robust conceptualisation of the organisational capability construct cannot be obtained without these components. Any component below the 30% was further analysed to ascertain its potential encapsulation by the important or main components. The common components identified engendered theoretical underpinnings in establishing specific domains or modes of measurement for the construct. Combined with Quinones et al. (1995) and Tesluk and Jacobs (1998)'s postulation of levels of specificity of construct measurement, a nomological network was developed to operationalise the organisational capability construct as it relates to design firms' ability to DfOSH. A nomological network establishes a linkage between the theoretical construct and its observable attributes in an attempt to operationalise the construct (Cronbach and Meehl, 1955).

5. Meaning and components of the organizational capability construct

The concept of organisational capability, in the extant literature, is construed in various ways by researchers. However, to measure organisational capability objectively and systematically, particularly as it relates to design firms with responsibilities for DfOSH, there is a need to provide a conceptual understanding of the construct. To this end, definitions in the literature are critically examined as the first step in its explication as indicated in Table 1.

Table 1: Definitions of organisational capability

Definition	Source
Ability of an organisation to integrate people, resources, processes, structures and cultures in projects, programmes and portfolios within a supporting governance and management system.	International Project Management Association (IPMA) (2016)
Arise from the coordinated activities of groups of people who pool their individual skills in using assets.	Sanchez (2004)
A combination of resources that creates higher-order competencies.	Madhok (1997)
A firm's collective physical facilities and skills of employees, and in particular, the abilities and expertise of the top management layers.	Chandler (1990)
Complex bundles of skills and collective learning, exercised through organisational processes, that ensure superior coordination of functional activities	Day (1994)
The capacity to deploy resources by integrating knowledge, business processes and organisational learning	Mahoney and Pandian (1992)

A higher-order structure reflecting functions and integration	Verona (1999)
A set of business processes strategically understood to deliver value to the customer	Stalk, et al (1992)
A firm’s capacity to deploy its assets, tangible and intangible, to perform a task or activity to improve performance	Teece et al. (1997)
The firm attributes that enable organisations to coordinate and utilise their resources.	Barney (2002)
The ability to perform repeatedly a productive task which relates either directly or indirectly to a firm’s capacity for creating value through effecting the transformation of inputs into outputs	Grant (1996)
The collective skills, abilities, and expertise of an organization	Maier et al. (2012)
An organisation's capacity to deploy its assets, tangible or intangible, to perform a task or activity to improve performance	Maritan (2001)
The organisation's capacity and processes to deploy its resources to improve organisational performance by creating superior customer value	Nasution and Mavondo (2008)
Ability of a company to deploy resources for a desired final result	Helfat and Lieberman (2002)
Ability of an organisation to perform a coordinated set of tasks, utilizing organisation resources, for the purpose of achieving a particular end result.	Helfat and Peteraf (2003)
A firm's ability to perform a set of tasks using company resources	HassabElnaby et al. (2012)
Essentially a constituted high-level organizational practices used to coordinate the productive activities of the firm	Winter (2003)
Intangible assets consisting of competencies along with dynamics of integrating and deploying those competencies with inimitable resources across organizational boundaries to operate business	Hall et al. (2011)
Ability to combine different types of resources, especially firm-specific knowledge embodied in their employees, in order to create new resources that enable firms to achieve and sustain their competitive advantage.	Un and Montoro-Sanchez (2010)

The firm's ability to manage resources in order to gain competitive advantage	Rauffet et al. (2016)
The collective skills, abilities and expertise of the organization	Ulrich and Smallwood (2004)

Organisational capability as a construct has its roots in the resource-based view (RBV) theory, which mainly argues that a firm is a bundle of heterogeneous resources and capabilities, which supports competitive advantage and explains the variance in performance across organisations (Barney, 2002; Un and Montoro-Sanchez, 2010). The RBV theory which founds organisational capability has been adopted in strategic management (Grant 1996; Barney, 2002), information systems (Andreu and Ciborra, 1996; Caldeira and Ward, 2003) and other fields of research in explaining the ability of organisations to meet customer needs. With the DfOSH concept gaining momentum and informing regulations in the UK and other parts of the world, the ability of design firms to develop capability for DfOSH will set them apart in the future market as far as the construction industry is concerned.

An analysis of the various ways in which researchers have attempted to conceptualise the organisational capability construct reveals certain common components of the construct. One of such common elements is *resources*. Out of the 22 studies reviewed, 19 construe organisational capability from resources perspective as indicated in Table 1 and the Appendix. The resources, as referred to here, include tangible ones as physical assets, employees together with their skills, knowledge and experiences (Ulrich and Smallwood, 2004; Un and Montoro-Sanchez, 2010) as well as intangible ones such as organisational processes, learning and reputation (Barney, 2002; Rauffet et al., 2016). As indicated shown in Table 1 and the Appendix, the component of *physical facilities* is suggested once. However, broadly, a firm's facilities can be considered as part of its resources (Un and Montoro-Sanchez, 2010).

The resources on their own are not productive (Grant, 1996) and require to be organised in such a way that value can be captured from them (Barney, 2002). In other words, the ability to organise these resources to ensure the superior performance of a task or fulfillment of a goal underpins their value. Hence, out of the 22 studies reviewed, 12 suggest *ability* while 15 suggest *integration* in the explication of the organisational capability construct as shown in Table 1 and the Appendix.

Verona (1999) classify organisational resources as either having functional or integrative capabilities. The former allows the organisation to deepen its technical knowledge (Verona, 1999) while the latter acts as an adhesive by drawing salient knowledge from external sources as well as blending the different technical competences developed in various units in the organisation (Teece et al., 1997). The component *attributes* was suggested once as indicated in Table 1 and the Appendix. However, generically, attributes as indicated in Barney (2002)'s conceptualisation of organisational capability can also be construed as firm's ability.

The ability to integrate organisational resources to perform a task or fulfil a goal must happen within and under a certain governance and management system. Hence, out of the 22 studies reviewed, 10 suggest *governance and management system* as a critical component in understanding the organisational capability construct as indicated in Table 1 and the Appendix.

Further, in the conceptualisation of the organisational capability construct, as indicated in Table 1 and the Appendix, considerations have to be made to the objects of organisational capability – well-executed tasks and value to the customer. Thus, out of the 22 studies reviewed, 8 suggest *task* while 10 suggest *value* or *superior performance* of tasks as shown in Table 1 and the Appendix. Organisational capabilities are required of firms, particularly design firms, because tasks are required by clients to be well-executed. In other words, value (as required by clients or customers) drive organisational capabilities (Helfat and Lieberman, 2002). Therefore, in explicating the organisational capability construct, considerations need to be made to the object and expected value that emanates from organisational capability.

Conclusively, based on the analysis of prior conceptualisation of the organisational capability construct, six main commonalities or components emerge in how the construct organisational capability is construed by prior researchers. These are: resources, ability, integration, governance and management system, task, and superior performance. None of these conceptualisations, as indicated in Table1 and the Appendix, construes organisational capability from the perspective of all these six main commonalities or components at the same time. Again, since there is no firm agreement on the definition or conceptualisation of the construct, at least from literature perspective and to provide a more robust understanding of the organisational capability construct, this study proceeds to define organisational capability as the firm's ability to integrate resources, both tangible and intangible, within a governance and management system to a ensure superior performance of a task. This definition is necessary to provide a consistent and systematic basis for the measurement of the organisational capability construct.

6. A framework for organisational capability measurement

The development of a framework for the measurement of organisational capability is based on Quinones et al. (1995)'s framework which was later extended by Tesluk and Jacobs (1998). Quinones et al. (1995) and Tesluk and Jacobs (1998) adopted a levels approach in the development of a framework for the measurement of worker experience. A levels perspective demands an appropriate definition of constructs and the domain of interest (dimensions of construct) as well as the level of measurement specificity (Klein et al., 1994). A levels perspective forces the investigator to think conceptually about the various levels of specificity as well as possible cross-level effects or domains (Quinones et al., 1995; Tesluk and Jacobs, 1998).

This framework elicits understanding by ensuring congruence across conceptualisation, operationalisation and interpretation of the organisational capability construct. Therefore, the first step in the process is to develop a framework that indicates the domain of interest as well as the measures that may be appropriate for each "cell" in the framework. The framework essentially indicates the main dimensions that describe the various measures of organisational capability as well as the different levels of specificity within each domain (Quinones et al., 1995; Tesluk and Jacobs, 1998). This approach juxtaposes the domains or mode of measurement of the organisational capability construct with the specific level where performance is required in order to ascertain the fine-grained or specific organisational capability measure in question. In that sense, an opportunity is provided to ensure congruence and effective operationalisation of the organisational capability construct in a nomological network. The nomological network has two main dimensions as *measurement mode* and *level of specificity*.

Considering the measurement mode dimension, recently, Manu et al. (2019) empirically identified six main categories of attributes constituting organisational capability of design firms, having responsibility for design to minimise OSH risks on construction projects as: *competence* (skill, knowledge and experience of the organisation's design staff); *strategy*; *corporate experience*; *systems* (processes and procedures); *infrastructure* (physical and information communication technology); *collaboration* (inter and intra-organisation). Their study makes a useful contribution in this area by, empirically, identifying domains or modes of measuring the organisational capability construct.

Many researchers have emphasised the human resource as a determinant of organisational performance (Karami et al., 2004; Chang and Huang, 2010). Manu et al. (2019) reference to competence corroborates an earlier study by Duhan (2007) who proposed a three-level organisational capability model. Duhan (2007)'s model indicates that the skills and knowledge of the employees, at the individual level, determine the core competence of the organisation at the intra-organisational level. Further, the core competence determines the capability of the organisation at the business level. Hence, in this framework, *competence* is viewed as a domain in which organisational capability could be measured.

Organisations usually integrate resources (O'Regan and Ghobadian, 2004) through processes and procedures to undertake tasks to fulfil goals. This may require both intra and inter-organisational collaborations. This integrative ability manifests as an adhesive that pulls critical knowledge from the various units in the organisation as well as blending it with external sources (Cohen and Levinthal, 1990; Teece et al., 1997) to undertake a task or fulfil a goal. Again, since capabilities are also composed of knowledge, their "main source" is learning that takes place within the organisation (Prahalad and Hamel, 1990; Leonard-Barton, 1995; Andreu and Ciborra, 1996; Teece et al., 1997; Wang and Ahmed, 2003; Chiva et al., 2007; Imran et al., 2016) and such as may be occasioned by external sources. Teece et al. (1997) indicate that organisations will need to reconfigure, consistently, both their internal and external competences in order to stay relevant in the rapidly changing economic and business environments. However, it is through learning that this reconfiguration can take place. Learning emanates from the activities undertaken by employees (Leonard-Barton, 1995; Chiva et al., 2007; Imran et al., 2016) in conditions of uncertainty, complexity, and conflict (Amit & Schoemaker, 1993) and requires social interaction for the continuous conversion of tacit and explicit knowledge (Nonaka, 1994). In that sense, *learning* can be considered as one of the domains of measuring organisational capability.

Organisational reputation is considered a capability that creates an advantage for organisations as it is difficult to acquire from the external environment (Chen and Lee, 2009; Zaidi and Othman, 2014) due to its intangibility (Ayuso et al., 2006). However, organisational reputation does not just happen. It is a function of time and functional superiority. Essentially, an organisation's cumulative-superior performance of a task or fulfilment of a goal builds or establishes its reputation in a positive sense. Again, this provides an opportunity or another lens to understand how to appropriately measure the organisational capability construct. *Reputation*, which is a benefit of superior performance of a task over time, is then being considered a domain in the measurement of organisational capability.

The organisation's ability to deliver superior performance, consistently, hinges on its managerial skills at resource selection, development (Sirmon et al., 2007), maintenance and retention. Again, for a consistent delivery of superior performance, there will be a need for a top layer of management that provides perspectives (IPMA, 2016) as well as creating and supporting values or culture that promote learning. The governance and management system, thus, does not only provide a substrate for learning but also provides a curative function to guide the optimal deployment of resources. In that sense, *governance and management system* can be considered as a domain for measuring organisational capability of design firms.

In Manu et al. (2019)'s empirical study on the key attributes of organisational capabilities for design firms with responsibility for minimising OSH risks on construction projects, they indicate one of the attributes as *infrastructure*. The infrastructure attribute, they indicate, involves both physical and information and communication technology (ICT) infrastructure. The rapidly changing working environment is increasingly being reliant on ICT. Essentially, ICT improves organisational processes (Porter, 1985; Koc and Bozdag, 2017) and enhances the productivity of human resource at the workplace. Organisational infrastructure required to deliver superior performance and to create value for the customer or the client does not only consist physical and ICT infrastructure, but also financial, control and planning systems (Porter, 1985; Koc and Bozdag, 2017). *Infrastructure* then can be considered as one of the modes of measuring organisational capability.

Quinones et al. (1995) and Tesluk and Jacobs (1998) in their measurement of work experience construct considered the level of specificity of the construct at the levels of task, job, team, organisation and occupation. However, in projectized environments, as the case is with design firms, the level of specificity of organisational capability is considered at the levels of task or activity; project; programme and portfolio (PMI, 2017; IPMA, 2015; IPMA, 2016). As indicated in Figure 3, each of the modes of organisational capability can be operationalised at four levels of specificity (task, project, programme and portfolio) creating a 5 X 4 nomological network for measuring organisational capability. Illustrations of measures of organisational capability, represented in each cell, are subsequently discussed. Firms with responsibility for design can vary in their level of organisational capability with respect to the performance of specific tasks. First, design firms can vary in the task competence of their employees. The skills, knowledge and experience of employees of design firms may differ. For example, a design firm may have a mix of employees who have in-depth skills, knowledge and experience in the performance of tasks related to OSH risk management at the pre-construction phases of projects as opposed to other firms. Second, design firms may vary in their accumulation or how much learning has taken place in the performance of OSH risk management tasks. Interactions among employees (under conditions of uncertainty, complexity and uncertainty) on OSH risk management tasks may engender new ideas and insights as a result of collective wisdom. However, organisations may differ in the arrangements that exist to capture and consolidate these new ideas and insights that emanate from such interactions, particularly at the OSH risks management task level. Further, design firms can lose skillful, knowledgeable and experienced employees. In that sense, it is the accumulated OSH risk management learning, at the task level, independent of any individual or employee that can guarantee the organisational capability of a firm and most design firms can differ significantly on this.

Third, design firms can vary in their reputation of OSH risk management tasks performances. Some may have excellent records of OSH risks management task performance in terms of novelty and superior performance while others may have poor records in same. Fourth, design firms can vary in the governance and management systems in place for the performance of OSH risk management tasks. Some may have policies and culture that promote doing things right the first time (Kano, 1993; Teece, 2017), even if more time may be required, while others may have no such policies and embark on quick fixes. Again, in organisations, certain individuals or teams may have unique abilities in performing certain tasks. The governance and management systems in place to get such individuals and teams to perform tasks that match their unique abilities may vary among design firms.

Level of Specificity

Portfolio	Portfolio skills, knowledge and experience of employees	Portfolio learning records	Portfolio reputation	Portfolio governance and management system	Portfolio infrastructure arrangement
Programme	Programme skills, knowledge and experience of employees	Programme learning records	Programme reputation	Programme governance and management system	Programme infrastructure arrangement
Project	Project skills, knowledge and experience of employees	Project learning records	Project reputation	Project governance and management system	Project infrastructure arrangement
Task	Task skills, knowledge and experience of employees	Task learning records	Task reputation	Task governance and management system	Task infrastructure arrangement
	Competence	*Learning*	*Reputation*	*Governance and management system*	*Infrastructure*

Measurement Mode

Figure 3: A conceptual framework of occupational capability measures

Finally, design firms may vary in their possession of infrastructure for the effective performance of OSH risk management tasks. Some organisations may have more infrastructure (physical, ICT, financial, planning and control systems) for the performance of OSH risk management tasks as compared to others. Again, the incentive or reward schemes available in organisations for novelty and superior performance of DfOSH tasks can all be underlying features or infrastructure (Amin and Cohendet, 2000; Yahya and Goh, 2002) embedded in design firms for optimal OSH risks management. This can vary significantly among design firms.

At the level of project specificity, differences can exist among design firms in respect of organisational capability. First, the skills, knowledge and experiences of design firm employees may vary in respect of projects. For example, the skills, knowledge and experience set of a design firm employees may be more within the domain of hospital buildings as opposed to shopping malls. Second, design firms may vary in organisational capability from the learning they have accumulated on projects. A design firm may have executed several projects in the past but may not have any concrete arrangements in place to capture learning on such prior projects. This undermines the ability to build and increase organisational process assets (Adaku et al., 2018) which can benefit future projects in terms of optimal decisions. Third, design firms can vary in terms of their reputations for projects. OSH risks management features embedded in project designs, by design firms, may reflect novelty and value for clients. Such cumulative positive decisions may lead to project awards and establish some level of reputation among construction project clients. There may be some design firms who may have never won such awards for optimal OSH risk management decisions for their designs. Fourth, design firms can vary on project governance and management system. While some design firms have, in place, robust governance and management systems to select and assemble the requisite employees to deliver projects with optimal OSH risk performance, others may lack such systems. Further, some design firms may not have the requisite policies to guide project team members in the delivery of projects that minimise OSH risks (Manu et al., 2019). Finally, design firms can vary on the infrastructure that are made available for delivery of OSH risk optimal projects. For example, some design firms may have, in place, available infrastructure (physical facilities; state-of-the-art ICT resources and tools such as building information modelling [BIM]; financial, planning and control systems) for effective OSH risk management at pre-construction stages of projects. On the other hand, there may be some design firms who lack or have inadequate infrastructure for the same purpose. The incentive schemes, at the project level, to ensure effective OSH risk management during designs can be underlying features or infrastructure (Amin and Cohendet, 2000; Yahya and Goh, 2002) that can support safe designs. Design firms, generally, can vary on this.

Differences in organisational capability can also exist at the programme level of specificity. First, the skills, knowledge and experiences of design firms can vary in terms of programmes. Some project clients may require multiple or a group of projects to fulfill certain objectives that otherwise may not be possible with individual projects (IPMA, 2016; PMI, 2017). This makes the programme level of specificity necessary in the construction industry. Some design firms may have employees with competence at this level while others may not have and this can establish a difference among design firms in respect of organisational capability. Second, how design firms have sought to accumulate learning on programmes can establish differences among them. For instance, two design firms may be involved in similar programmes but may differ in arrangements and how learning is captured and consolidated on the programmes. One may have effective arrangements to capture and consolidate learning, so as to benefit future programmes, while the other may lack or have inadequate arrangements for same. Third, design firms can vary on programme reputation. For example, a design form may demonstrate consistent superior performance in the handling of multiple and complex projects and may have a reputation for that while another firm may show inconsistent performance, even with normal and less complex programmes.

Fourth, design firms can vary on programme governance and management systems. Delivering multiple projects requires adequate coordination and integration efforts. Hence, the governance and management system in place to engender effective coordination and integration are key to a programme success, particularly from OSH risk management perspective. A design firm may have a robust governance and management system for this while the other may not have. Lastly, design firms can vary on the arrangement of infrastructure for programmes. For instance, while some design firms may have elaborate infrastructure (physical facilities; start-of-the-art ICT resources and tools; financial, planning and controlling systems), others may lack or possess inadequate infrastructure for effective programme OSH risks management, particularly at the pre-construction stages of the projects development processes. Again, at the level of a programme, the degree of complexity (in respect of the different parts that ought to be effectively coordinated or integrated to ensure a successful programme delivery) increases. Thus, somewhat incentive schemes embedded in design firms to incentivise the programme team members will be critical underlying features or infrastructure to ensure coordination and integration at the programme level. Again, design firms can differ on this dimension.

At the level of portfolio specificity, differences exist among design firms in respect of organisational capability. First, the portfolio competence of design firms' employees can vary. For example, the skills, knowledge and experiences of the employees of a design firm may be related to a portfolio in the area of resort or recreational infrastructure while another design firm may have the portfolio competence of its employees in the area of transportation infrastructure. Second, the amount of and how learning have been accumulated on portfolios by design firms can vary. Some design firms may have extensive learning records as well as effective arrangements to capture learning on portfolios while others may have managed several portfolios but lack or have inadequate records as well as ineffective arrangements to capture learning. Third, differences can exist among design firms in respect of portfolio reputation. Some design firms may have handled diverse portfolios (recreational or resort infrastructure, transportation infrastructure, etc) and may have demonstrated consistent and superior performances in the handling of these portfolios. As a result these firms may have established and earned reputation in that regard. On the hand, other design firms may have handled limited portfolios and perhaps have not been able to demonstrate consistent and superior performances in the handling of those portfolios. In that sense, there can be a reputation deficit. Fourth, design firms can vary in respect of the governance and management systems in place for the management of portfolios. Some design firms may have elaborate governance and management systems, in place, for effective integration and deployment of resources on portfolios. This could be in the form of policies, culture and value systems that engender desirable outcomes on portfolios (Bryde, 2003; Stare, 2011). Conversely, there may be some design firms that have limited and inadequate governance and management systems in respect of portfolio handling. Fifth, design firms can vary on the infrastructure required for the handling of portfolios. While some design firms have extensive infrastructure (physical; ICT resources and tools; financial, planning and controlling; incentive mechanisms) for the handling of portfolios, others may be deficient in this (Porter, 1985; Koc and Bozdag, 2017; Manu et al., 2019).

7. Discussion and pointers for future directions for design firms' organisational capability research

The construct of organisational capability as it relates to firms with responsibility for design, particularly for optimal OSH risks management, is considered as being multi-dimensional in its measurement. Understanding organisational capability from a single or narrow perspective can potentially undermine a useful measurement of it. Again, a narrow view of it can also impair the judgements and decisions of project clients who have to match project risk considerations to designers based on their capabilities. Further, the organisational capability construct, in respect of design firms, must be considered as a multi-level one. Capabilities of design firms cannot be assumed to be uniform at all levels (from a task to a portfolio level). The capabilities that are required at the task level may not be the same as required at the portfolio level. In that sense, for optimal decision-making on the part of project clients intending to clarify the DfOSH abilities of design firms, it will be appropriate to ascertain organisational capability at the various levels of performance specificity or requirement.

The organisational capability construct, as it relates to design firms must be considered as dynamic (Kianto, 2008; Teece, 2012). Capabilities, as they reside in firms, can be considered as assets (Andreu and Ciborra, 1996; Mentzas, 2004; Adaku et al., 2018). In that regard, it can increase through deliberate and conscious efforts by firms or deteriorate as a result of lack of governance and managerial perspective and neglect. Over time, the organisational capabilities of design firms can increase or deteriorate along the *mode of measurement* or the *level of specificity*. Hence, an industry framework that seeks to capture the dynamics of organisational capability of design firms will be a useful one. Such frameworks could be in the form of capability maturity models. Recently, Poghosyan et al. (2020) have conducted a study that sought to develop a web-based occupational safety and health (OSH) capability maturity indicator for the assessment of designers. This and similar studies are in the right direction in respect of capturing the dynamic nature of organisational capability of design firms.

The proposed framework for the measurement of the organisational capability construct in respect of design firms can inform the criteria for the assessment and selection of designers, particularly from the client perspective. Some countries have public specifications that assist clients in assessing and selecting design firms. For example, in the UK, the publicly available specification (PAS) 91 is one such instrument for construction-related procurement. A private sector initiative like safety schemes in procurement (SSIP) in the UK is also another scheme to complement PAS 91. Further, the suggested framework can also serve as a guide for design firms intending to build their organisational capability regarding DfOSH. In this way, an insight is provided as to which areas – constituting organisational capability – can be focused on as well as the levels of performance these abilities are required in the attainment of organisational capability. It is a broad and comprehensive framework for the measurement of the organisational capability construct. Future studies on organisational capability of design firms should focus on testing the measures (particularly the attributes within the cells) of the organisational capability construct empirically to distill the most relevant ones having regard to the current practice. Further, in such an empirical test, attention should be paid to what constitutes each measure as well as the evidence or indicator that must be adduced to reflect that measure in practice.

In some countries where there are regulations to ensure DfOSH in the construction industry, requirement for organistional capability of design firms seems to target the project level of specificity or performance requirement. An example is the Construction (Design and Management) (CDM) 2015 regulations in the UK. Clearly, the focus of the regulators in respect of the regulations is to provide a generic framework for the effective management of OSH risks in the construction industry. However, inadvertently the focus seems to be on only projects. Meanwhile the complexity of the current business environment, sometimes, makes it impossible to realise a corporate goal with only one project. A typical example is the London 2012 construction programme for the Olympic and Paralympic Games. Webster (2013) indicates that for optimal performance of OSH on the programme, the Olympic Delivery Authority (ODA) appointed a CDM integrator to manage and coordinate several CDM coordinators on projects under the programme. This highlights the organisational capability requirement of design firms (as far as OSH is concerned) beyond the project level of specificity. Hence, regulations should emphasise performance requirement beyond the project level of specificity in respect of design firms' organisational capability. Further studies on DfOSH capability maturity model like Poghosyan et al. (2020)'s study, should consider capability maturity models at different levels of specificity or performance.

As earlier indicated, the organisational capability of design firms, with responsibility for effective OSH risks management, can increase or deteriorate. Thus, future studies on organisational capability should investigate the enablers or constraints of organisational capability of design firms. Further, future studies are invited to also investigate the interrelationships between the measurement modes and the interdependencies of levels of specificity indicated in this framework.

This proposed framework or nomological network to measure the organisational capability of firms with responsibility for DfOSH cannot be deemed to be complete. Thus, further studies will be invited to extend the network to deepen our understanding of and ability to measure the organisational capability construct as it relates to design firms.

8. Conclusions

The issue of OSH risk on construction projects has been a thorny one among stakeholders of the industry. This has spawned a number of investigations among both scholars and practitioners as to how to deal with this risk, effectively. One of the insights from the investigations points to the DfOSH initiative. However, there is a paucity of knowledge in the extant literature as well as a misunderstanding in practice as to what specifically constitutes the DfOSH capability of design firms and most importantly how to measure it. This study has, thus, sought to deepen knowledge in this area in a number of ways. First, it conceptualises the construct organisational capability as a basis for its meaningful operationalisation. Second, it provides a comprehensive framework for an effective operationalisation of the construct as it relates to design firms. It does so by presenting organisational capability, in respect of DfOSH, as a multi-dimensional construct that can be operationalised at various levels of specificity. By this approach, a congruence is provided for a meaningful conceptualisation and operationalisation of the construct. Third, it signposts further studies, both theoretically and empirically, that can be undertaken to push the knowledge frontier of the DfOSH initiative outward. Such future studies should seek to meaningfully extend the nomological network by looking into the domains or mode of measurement as well as the levels of specificity of the organisational capability construct in respect of DfOSH.

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Appendix:

Table 2: Components of organisational capability construct

SN	Study/Literature	Organisational capability components							
		Resources	Integration	Governance and management system	Superior performance	Facilities	Task	Attributes	Ability
1	International Project Management Association (IPMA) (2016)	X	X	X					X
2	Sanchez (2004)	X	X						
3	Madhok (1997)	X	X	X					
4	Chandler (1990)	X	X	X		X			X
5	Day (1994)	X	X	X	X		X		
6	Mahoney and Pandian (1992)	X	X	X					X
7	Verona (1999)		X	X			X		
8	Stalk, et al (1992)		X	X	X				
9	Teece et al. (1997)	X			X		X		X
10	Barney (2002)	X	X					X	
11	Grant (1996)	X			X		X		X

12	Maier et al. (2012)	X	X						
13	Maritan (2001)	X			X		X		X
14	Nasution and Mavondo (2008)	X		X	X				X
15	Helfat and Lieberman (2002)	X			X				X
16	Helfat and Peteraf (2003)	X	X		X		X		X
17	HassabElnaby et al. (2012)	X					X		X
18	Winter (2003)		X	X			X		
19	Hall et al. (2011)	X	X						
20	Un and Montoro-Sanchez (2010)	X	X		X				X
21	Rauffet et al. (2016)	X		X	X				X
22	Ulrich and Smallwood (2004)	X	X						
	Total count in studies	19	15	10	10	1	8	1	12
	Proportion of total studies	86%	68%	45%	45%	0.05%	36%	0.05%	55%

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