REDEFINING DESIGN IN CONSTRUCTION

Mustafa Selçuk Çıdık[1] and David Boyd[2]

[1] *School of the Built Environment and Architecture, London South Bank University, 103 Borough Road, London SE1 0AA, UK*

[2] *School of Engineering and the Built Environment Birmingham City University, City Centre Campus, Millennium Point, Birmingham B4 7XG, UK*

Several theoretical framings have been proposed regarding the nature and process of designing but these mainly see design as a creative activity. However, designing in construction is a collective undertaking that involves not only 'creating' discipline-specific parts of the design but also 'organising' them to ensure consistency and coherence. Nevertheless, organising design in construction is under-theorised, and there are no clear explanations of what constitutes design collaboration and how it is different from designing. These gaps imply not only a shortcoming for managing design in construction, but also a difficulty for developing technology that effectively supports it. Therefore, this paper adopts a practice-focused approach to explore the interdisciplinary design interactions in a project from an organisational point of view. This develops further insight into the natures and processes of designing and design collaboration in construction, thus informing the management of design. When seen from a practice-based perspective, multidisciplinary design development becomes an ongoing process of re-establishing 'a shared sense of purposefulness' that enables both autonomy of, and consistency between, different design disciplines. This provides an explanation of the interdependency between specialist knowledge and interdisciplinary interactions. Thus, the paper develops definitions of design and design collaboration in construction that are centred on 'organisation' rather than 'creativity'. Implications for technology development and management are outlined.

Keywords: design management, organisational analysis, research methods

INTRODUCTION

Design in construction requires collective working of multiple professionals from different disciplines. However, different professionals see design differently based on their discipline-specific perspective to make sense of and develop their part of the design. Hence, defining and managing the practice of design in construction is problematic as both autonomous (i.e. discipline-specific) and collective (i.e. interdisciplinary) aspects of it need to be considered in an interrelated way. This implies that the nature and process of interdisciplinary design interactions need to be better understood to establish a definition that explains both the autonomy and collectivity inherent in the practice of construction design. Such an understanding of design in construction is critically needed to develop practically-relevant support technologies and management approaches.

Wider literature on design provides theorisations of design that are centred upon the creative designer (e.g. Alexander 1964), performance of the designed artefact (e.g. Simon 1999/1969) or creative development process (e.g. Le Dantec 2010). Although these present a range of theoretical lenses to establish design as a peculiar artistic or professional activity, they hardly inform the management of or technology development

[1] selcukcidik@gmail.com

This paper was presented as a working paper at the ARCOM 2017 Conference, Cambridge, UK, 4-6 September 2017. Please contact the authors before citing

for multidisciplinary design in construction (Kvan 1999; Koskela *et al.,* 2002). .Thus, until recently, construction design management has largely been studied either as architectural management (Emmitt 2016) or as technical project management which relies on discipline-based breakdown of design tasks (Zerjav 2012). Besides, the concept of 'design collaboration' has been under-theorised and used as a generic term to mean different things in different studies (Kvan 2000).

This paper adopts a practice-based approach (Feldman and Orlikowski 2011), and builds theory upon everyday interdisciplinary design interactions in a construction project to redefine design in construction from an organisational point of view. It builds on the view that interdisciplinary design interactions are not the means for integrating isolated parts of the design 'created' by different design practitioners. Rather, the 'practice of design' suggests that design develops through 'overwhelmingly-intertwining' interdisciplinary interactions which present a continuous path of unfolding decisions and activities (Zerjav 2012). Consequently, the paper aims to set 'design' (in construction) as an organisational phenomenon to balance the current theorisations focusing on creativity, and enable insights into its day-to-day management and support by technology. It uses empirical data from an educational building project in the UK at its detailed design stage. The analysis provides insights into how a sense of 'what to do' and 'what ought to be done' was established and maintained in the project. The paper reveals that multidisciplinary design development is an ongoing process of re-establishing 'a shared sense of purposefulness' that enables both the autonomy of, and consistency between, different design disciplines. Based on this, it is argued that more critical practical management of interdisciplinary interactions is crucial for effective design management, and that the focus of the collaborative technologies must shift away from data-integration.

THEORISING DESIGN

According to Minneman (1991), design research appeared as an individual topic of research in the 1950s due to the doubts about whether increasingly complex engineering projects could be rationalised to be managed. Therefore, at the early times of design research, the dominant debate was around the roles of rationality and intuition in design. For example, Alexander (1964) focused on conceptualising 'the designer' and claimed that he/she needs to employ a mixture of intuition and rationalism to develop the correct form. On the other hand, Simon's (1999/1969) unit of analysis was 'the designed artefact', and he developed a conception of design based on the designer's limits of rationality in considering the possible future conditions to which the artefact would be exposed.

However, the centrality of rationalism in this debate attracted criticism. One of the best-known critiques came from Rittel and Webber (1973) who argued for a conception of design centred on the 'design problem' rather than the rationally designed artefact or privileged designer. The authors claimed that design problems must be differentiated as 'tame' and 'wicked' when conceiving design. Tame problems are the ones that are suitable to be understood and resolved rationally in certain pre-agreed terms. However, the resolution of 'wicked' problems do not have definitive formulation and relies on intuition because "the information needed to understand the problem depends upon one's idea for solving it" (Rittel and Weber 1973: 161).

The criticisms around the rationalistic views of design gave birth to a 'second generation' of analytical methods that focused on what designers do and how they think (Coyne 2005; Kimbell 2011). This shifted the ground to an empirical consideration of how professional rationality is established, giving a profession a unique character and a texture that can be

recognized externally in rejection of a rationality based on an abstract logic (Coyne 2005). The work of Schön (1983) is well-recognised among this so-called 'second generation' of analytical methods. Schön (1983) argues that problems are not given in professional practices, and therefore, professionals 'frame' problems based on their judgements. According to Schön (1983), these judgements, which he calls 'professional artistry', enable professionals to tackle unique problems in practice. Thus, he claims that design is a 'reflective conversation with the situation' which involves reflectively acting on the situation to 'frame' the problem, and so advancing its perception (Schön 1983).

Since 1990s, several theoretical viewpoints conceived design based on the social and material conditions that underpin either the 'rationality' or 'professional artistry' of design practitioners. For example, Bucciarelli (1994) conducts an ethnography and reveals that the engineering design is not an instrumental process but a historically situated social process that is full of uncertainty and ambiguity. Julier (2006) argues for studying design as a culture that is open to the effects of the immediate context of designing, but also shaped by pervasive norms, technologies, organisational patterns, and morality which enable universal applicability of design to a variety of unique issues. Similarly, Le Dantec (2010) conceives design as a social creation relying on 'cultural cognition' to account for the shared understandings in design situations as well as the moral and practical purpose that are ascribed to the shared activity.

The practice-based view of design, which is adopted in this paper, is another theoretical approach that considers the socio-cultural, historical, and material embeddedness of design to explain the enactment of 'rationality' or 'professional artistry' that is argued to underpin design. Nevertheless, uniquely, its unit of analysis is 'practice' and so it emphasises the observable interactions of practitioners (with social and material entities) (Kimbell 2009; 2011). However, so far, practice-based studies of design have been preoccupied with investigating design situations to unpack 'creativity' inherent in design (e.g. Luck 2012) rather than conceiving design as an organisational phenomenon.

RESEARCH ON ORGANISING DESIGN IN CONSTRUCTION

The previous section has shown that theoretical approaches to design are fragmented and divergent both philosophically and methodologically, and they are dominated by ideas of design as a creative activity. Also, there are surprisingly few studies that aim to build theory about the nature of design in the construction industry. Some contributions (e.g. Koskela *et al.,* 2002; Baudains *et al.,* 2014) give a critique but do not converge into wider theories. Additionally, as suggested by Emmitt (2016) individual studies on organising and managing design in construction are non-accumulative and confused in terms of their concepts and theoretical directions. Therefore, it is difficult to establish theoretical and conceptual ground(s) when studying construction design as a collective and multidisciplinary undertaking.

A reason for this difficulty has been identified by Bygballe and Jahre (2009) who suggest that, in the construction industry, there are different value creation logics applied by different professions, which can be in tension with each other. In line with this, Emmitt (2016) argues that construction design management has only recently started to be seen as more than discipline-based management of parts of the design. Zerjav (2012) joins Emmitt (2016) to criticise the view that engineering and architectural designs are fundamentally different in their nature, arguing that this assumption does not hold in practice. Consequently, both Zerjav (2012) and Emmitt (2016) suggest that design management in construction must be different from technical project management which relies on analytical reductionism (i.e. task-specification, -breakdown/isolation, and -

integration), implying a need for exploring how design practices are contingent on their organisation and management. In this context, 'design collaboration' has also become a disputed concept as pointed out by Kvan (2000) and Wang and Oygur (2010), who criticised the use of the concept with its simplistic taken-for-granted meaning, being unsupported by evidence and theory. This has negative implications on the development of information technologies, as it drives the development of technology that is inappropriate (Kvan 1999).

Consequently, there is a need to develop an organisational definition of design in construction that is grounded in everyday practices but that is also able to capture both the autonomy and the collectivity that are observable in project-level organisation. Zerjav (2012) argues that practice-based studies of design and design collaboration in construction have mainly provided descriptive accounts of everyday undertaking of design work. Hence, they do not converge into project-level theory that can guide effective practical management and support of multidisciplinary construction design. Therefore, this paper will explore the practice of interdisciplinary design interactions to take a first step to develop an organisational definition of design in construction.

METHODOLOGY

A practice-based research approach (Feldman and Orlikowski 2011) is adopted to develop organisational theory on multidisciplinary design in construction based on exploration of everyday interdisciplinary interactions. Design-as-practice (Kimbell 2009) is a theoretical perspective that avoids decontextualized (e.g. centred on designer, designed artefact, and so on) as well as abstract (i.e. centred on cognition, culture, and so on) explanations of design. The relational epistemology (Emirbayer 1997) employed in practice-based theorisation suggests that design, designed artefact, or designer are not fixed or universal categories of entities; and so they must not be defined as such through decontextualised and abstract explanations of practices. Rather, design, like any other practical undertaking, consists of a set of empirically observable, unfolding (i.e. path-dependent) interactions in practice which continuously re-configure designers' understandings about design situations, and thus providing their sense of 'what to do' and 'what ought to be done' (Nicolini 2012).

This implies that construction design can be seen as an organisational phenomenon in which the creation of the discipline-specific parts of the design and interdisciplinary interactions drive each other. Thus, such a practice-based approach also implies that design management must not be considered as a separate function performed by distinct 'design managers' that regulate the creative activities. Rather, it is an integral part of designing because, in practice, the activities of managing and developing design are interacting parts of the same organisational whole. So, they are socially and materially interrelated, and thus unfolding on and shaping each other. Consequently, a practice-based approach can be employed to develop empirically observable theory on organising design that would yield new definitions of construction design as an organisational phenomenon. Ultimately this can provide concrete explanations about the role and means of design management in the successful delivery of construction design projects, thus producing managerial knowledge that has practical application.

According to this approach, organisational structures and routines don't have an existence of their own as they are merely patterns of interactions resulting from certain courses of actions being repeated, and thus unfolding in certain ways in practice (Feldman and Orlikowski 2011). Therefore, structures of organisational life, including those in autonomous organisation of discipline-specific work and collective organisation of

project-wide design, are rooted in and continuously (re)-produced through everyday interactions in practices. This assumption implies an empirical orientation towards the exploration of interdisciplinary interactions in practice with an agenda of investigating how the sense of 'what to do' and 'what ought to be done' is established and maintained in construction design projects. According to the adopted practice-based approach, the answer to this question must be explored through an analysis that establishes interrelations between project-level patterns (i.e. routines) of interactions and practice-level instances of interactions. This is because, in practice, they are interconnected and drive each other (Nicolini 2012).

The paper uses findings from an educational building project in the UK at its detailed design stage. As part of a larger research project, the first author observed the project for 10 months and attended 23 interdisciplinary design meetings. The findings from the project will be presented in two sections. First the organisational environment of the project will be described with a focus on the patterning of the coordination activities to provide a basis for arguing about which activities were significant for the organisation to coordinate and how these were framed. Second, two events from practice will be presented to explore how the sense of 'what to do' and 'what ought to be done' were enacted and maintained in and through design situations. Associations will be made between the practice- and project-level findings. This will enable an organisational (re)-definition of multidisciplinary construction design that is based on everyday interdisciplinary practices, but that also explains the connection between the discipline-specific autonomous and the project-wide collective organisation of design. This new definition will yield a practice-based understanding of design collaboration as well as insights into design management and technology development.

INTERDISCIPLINARY DESIGN IN PRACTICE

A range of interdisciplinary design interactions at project-level

In the observed project, there were a variety of interdisciplinary interactions for design development. These interactions can be grouped under two main categories: face-to-face interactions, and remote interactions. Face-to-face interactions included scheduled meetings, spontaneous meetings, site visits, and informal conversations. Remote interactions included e-mail correspondences, telephone conversations, and those that involved the use of design artefacts such as checking, reviewing, and signing-off design documents and information models produced by other practitioners. These various modes of interaction were not well-defined instruments for problem-solving that were used to resolve specific and well-defined design issues. On the contrary, interdisciplinary interactions were almost always in flux and resolution of interdisciplinary design issues actually included iterative series of realisations, explorations, expressions, and planning through a number of emergent interdisciplinary interactions. In this regard, interdisciplinary interactions for design development almost always pointed to future interdisciplinary interactions and so framed them. A sketch sent as an e-mail attachment, a phone conversation about design criteria of a building system, a contested space in building (which surfaced in a previous meeting) could trigger planning for further interactions to resolve the unfolding issues and develop the design gradually.

Connected and unfolding nature of various kinds of interactions for design development implied that practitioners skilfully employed a range of face-to-face and remote modes of interactions. In practice, this meant they had to be aware of, and exploiting, different strengths and weaknesses of each available mode of interaction in a complementary way. For example, most episodes of discussion in regular design-coordination meetings

(DCMs) were concluded by agreeing on some action points involving further remote interactions, such as commenting on, or marking-up some design documents related to the topic of discussion. In such cases, face-to-face discussion of an issue (e.g. ventilation of a ground floor) complemented remote interaction about more-detailed aspects of that issue (e.g. reviewing the schedule of outlets on the ground floor) and vice-versa (i.e. remote interactions that resulted in discovering new issues created needs for face-to-face discussions).

Evolving range and nature of interdisciplinary interactions at project-level

The longitudinal study of the project revealed that the need for interdisciplinary interactions evolved during the observed detailed design stage of the project in both expected and unexpected ways. Practitioners responded to this by employing various modes of interactions in varying combinations based upon their perceptions of both the issue, and the strengths and weaknesses of each mode of interaction. Therefore, the skilful use of various modes of interactions depended on the appreciation of the changing needs of various designers along the design process. For example, the design team chose to increase the number of site visits during the observation period, which increased the number of references made to site visits during the discussions in DCMs. Moreover, the topics of the discussions that referred to site visits changed over the observation period revealing the changing nature of the circumstances that were considered relevant and important during site visits. There was a gradual change in the topics from design of specific building systems to the tests of the installed systems.

Importantly, most of the time practitioners knew that they would be dealing with changing types of issues, and also they knew the kinds of issues that they would have to deal with. Thus, these were expected issues. However, in DCMs, most of the time was spent for discussing and action-planning the unexpected and differently expected issues. Even the agenda structure of DCMs, which was consisted of two sections (i.e. 'previous minutes' and 'updates' sections), reflected this aspect. The 'previous minutes' section mainly dealt with making sense of, and planning for, the resolution of the unexpected or differently expected issues that were previously discovered. Whereas, the 'updates' section mainly included expected issues such as information and meeting requests between disciplines, updates about work-in-progress for each discipline, and so on. As a result, interdisciplinary interactions evolved in the face of a mixture of mutually expected, differently expected, and unexpected, needs for interacting. The available modes of interaction were skilfully used to respond to changing needs, which resulted in different ranges and natures of interdisciplinary interactions. Ultimately, this was an indication of the interdependence between discipline-specific work and interdisciplinary interactions because maintaining a progressive sense of 'what to do' and 'what ought to be done' in discipline-specific work depended on these evolving interdisciplinary interactions.

The nature and process of interdisciplinary interactions at practice-level

Event 1:
Apart from the atrium area, all the areas in the building were serviced through suspended ceilings. This was a very conventional system for such buildings, therefore the architect, the M&E consultant, and the M&E sub-contractor were experienced in their design and installation, and there were agreed design strategies in the project for working with them. However, for the board room, the client briefing stated that "the ceiling in board room will be different" and the architect specified a decorative wooden ceiling. This had serious implications on several other systems, thus, this single irregular ceiling type required much following coordination. For example, the chilled beams that were

specified for the board room arose as an issue. The complexity of the decision involved: the fixing details of both wooden ceiling and chilled beams, the efficiency of chilled beams when placed above the wooden ceiling, the laying direction of the individual wooden pieces and chilled beams, the colour of wooden ceiling and chilled beams (because the chilled beams would be visible from the gaps between wooden pieces). These issues all needed to be discussed at different occasions in DCMs between the architect who were responsible for the ceiling, the M&E consultant who specified chilled beams for that space, and the M&E sub-contractor who were supposed to deliver detailed design and do the installation. When this issue was first raised by a representative of the M&E sub-contractor, his first strategy was to establish the premises of this decision: whether the wooden ceiling was particularly specified by the client or the client only specified a different type of ceiling for which the architect had decided to have wooden ceilings. Once it was established that it was the client that led the architect to specify wooden ceiling, all the issues mentioned above needed to be coordinated due to the irregular character of wooden ceilings in the project.

Event 2:
At the beginning of the detailed design stage, the design changed significantly with the purpose of increasing the total net internal area of the building because of the request of the client. Although the previous service and architectural strategies were reviewed before the confirmation of the design change, some areas of the design needed to be coordinated in detail as they fell out of these general strategies. One example of this was about the servicing problems of the rooms in the corners on the floors above the ground level. The main servicing strategy for these floors was to pass the main services along the corridors on each floor, and distribute them into the rooms that open to the corridor. However, the rooms that were in the corners of each floor required additional coordination because they were in remote positions (i.e. largely isolated from the corridors) and their servicing needed to be specifically coordinated due to the number of the services that would have to pass through a very limited space. This issue stayed as an outstanding issue for long time as detailed drawings by the architect and the M&E sub-contractor were needed before the coordination could be done at the desired level of detail. The strategy followed in this situation was to coordinate one of the corner rooms in a very detailed way, and then to apply the agreed design principles to the other similar rooms. It had been thought that doing detailed coordination of all isolated rooms individually would take too much time.

DISCUSSION

Design in construction, as a collective undertaking of practitioners from various disciplines, is under-theorised, and for this reason practitioners lack the concepts and understanding for its practical management and support. A practice-based research approach suggests that design in construction is accomplished based on the sense of ‘what to do’ and ‘what ought to be done’ that is enacted in and through interdisciplinary interactions and professional contextual issues. The discussion will show that design is a developmental process contingent on the professional environment and what mattered most in interdisciplinary interactions is to maintain a ‘shared sense of purposefulness’, as implied by the consistency and coherence between different autonomous discipline-specific designs. The notion of 'shared sense of purposefulness' will be unpacked through an examination of how the unexpected or differently-expected issues and unknowns required significantly more interdisciplinary efforts to be resolved in comparison to the expected issues and unknowns. It will also reveal that because design was unfolding, the line between the expected and unexpected issues was relative and continuously shifting,

thus making the need for interdisciplinary interactions path-dependent and continuous. Ultimately, these results will enable a (re)-definition of construction design that is centred upon its organisation. Managerial and technological implications of this new definition will be outlined.

Redefining design and design collaboration in construction

The project-level findings revealed the continuous and path-dependent nature of interdisciplinary interactions in construction design with an emphasis on the practical concern of judging, establishing, or re-confirming the degree of familiarity of the design situations that were faced. The events provided additional insight by revealing how the familiarity of a design situation was judged in relation to interfaces between design practitioners. Event 1 revealed that numerous rooms with chilled beams did not require much interdisciplinary effort as a general coordination strategy was sufficient. This 'general coordination strategy' was formed through noticing the interfaces that needed to be considered by the parties that have a stake in that part of the design, and the negotiations about how these could be sorted. As soon as these were agreed, parties could proceed with their discipline-specific design without engaging in further effortful interdisciplinary interactions. However, when exceptions to the general coordination strategy arose (e.g. later in Event 1) much interdisciplinary effort was required to jointly re-establish the interfaces. Event 2 also provides an example of this path-dependent negotiation process by showing (i) how the rooms in the corner were irregular and their coordination required additional interdisciplinary effort; and (ii) how the coordination of multiple corner rooms was achieved through the detailed coordination of only one of them.

These findings suggest that design in construction is organised at interdisciplinary interfaces so that discipline-specific designs can be developed autonomously but also consistently and coherently. In the observed project, various design stakeholders were not interested in knowing everything about what others did neither were they interested in seeing the design from others' eyes. Also, they did not develop a 'shared understanding' as suggested by Valkenburg (1998). Rather they were interested in developing an awareness and familiarity of the interfaces between their parts of the design and others' parts of the design so that they could develop purposes which would enable them to further develop their discipline-specific design. This awareness and familiarity relied on two major resources in the observed events. The first was the previous individual experience, and the professional and institutional standards of practice. These provided an initial repertoire and guideline for where to look and how to operate at interdisciplinary interfaces. The second resource, which was equally important, was the jointly constructed shared past of interdisciplinary interactions in the project; this gave a joint appreciation of what led to the present. This significantly reduced the negotiations about potential ways forward that would be acceptable to the parties involved, thus creating a remarkable efficiency both for discipline-specific decision making and interdisciplinary interactions. Consequently, it is argued that, from a practice-based point of view, practitioners established and maintained a sense of 'what to do', and 'what ought to be done' by continuously re-establishing 'a shared sense of purposefulness'. Based on this explanation of design, design collaboration can also be reframed as the 'purposeful organisation of meanings attached to design'. This definition suggests that face-to-face and remote interdisciplinary interactions may or may not be collaboration depending on whether they play a part in establishing a shared sense of purposefulness.

Finally, the proposed practice-based views of design and design collaboration enable insights for the practical management and support of design in construction. This suggests that design management in construction should focus on supporting adequately everyday interdisciplinary interactions. Managerial efforts must acknowledge that these interactions are for establishing a shared sense of purposefulness required at design interfaces, and therefore do not necessarily need close-coupling of design practitioners. Although design standards, templates, and guidelines provide an important foundation for design to be accomplished, design management in construction must recognise that creating the adequate environment for design practitioners to jointly construct a shared past is of utmost importance for successful design. In this context, collaborative design technologies in construction, such as building information modelling software, must support practitioners in establishing and confirming a shared sense of purposefulness. This implies that the focus of collaborative technology development must shift away from integrating every possible piece of design data, to developing digital environments that can support people in their interactions by helping create a shared sense of purposefulness. Also, this paper suggests that the current trend of promoting the replacement of face-to-face interactions with remote interactions through digital means must be re-evaluated. Supporting design collaboration cannot be thought separate from supporting establishment of a shared past through continuous interdisciplinary interactions. Therefore, exchanging digital models between design practitioners without a conscious planning for other kinds of interactions would not help collaboration and could even be harmful to collaboration.

CONCLUSIONS

Theory on the nature of design is diffuse in its philosophical and methodological approaches and does not provide enough insight for the practical management of the collective activity of multidisciplinary design. Besides, theory on organising construction design mostly focuses either on discipline-specific management of design or relies on traditional project management which is based on analytic reductionism criticised by previous work. Thus, the practitioners cannot gain an understanding for the effective support and management of design in construction. This paper demonstrated how practice-based approach can be used to develop organisational theory on construction design that jointly considers the autonomous discipline-specific work and the collective project-wide design. The emerging definitions of design and design collaboration emphasise the necessity of maintaining a 'shared sense of purposefulness'. Hence, they provide valuable insights into the understanding of multidisciplinary design in construction as well as its effective management and support. Therefore, the paper advances the previous work on construction design management as well as the practice-focused studies of design which mainly focus on developing thick descriptions of design situations rather than building organisational or management theory. Future research will further employ this approach to develop a critical agenda to change current design management and technological support strategies. Key to doing this is the acknowledgement that construction design relies on continuous re-establishment of a shared sense of purposefulness.

REFERENCES

Alexander, C (1964) *Notes on the Synthesis of Form*. Cambridge, MA: Harvard Univ. Press.

Baudains, P, Bishop, S, Duffour, P, Marjanovic-Halburd, L, Psarra, S and Spataru, C (2014) A systems paradigm for integrated building design. *Intelligent Buildings International*, **6**(4), 201-14.

Bucciarelli, L L (1994) *Designing Engineers*. Cambridge, MA: MIT Press.

Bygballe, L E and Jahre, M (2009) Balancing value creating logics in construction. *Construction Management and Economics*, **27**(7), 695-704.

Coyne, R (2005) Wicked problems revisited. *Design Studies*, **26**(1), 5-17.

Emirbayer, M (1997) Manifesto for a relational sociology. *American Journal of Sociology*, **103**(2), 281-317.

Emmitt, S (2016) The construction design manager: A rapidly evolving innovation. *Architectural Engineering and Design Management*, **12**(2), 138-48.

Feldman, M S and Orlikowski, W J (2011) Theorizing practice and practicing theory. *Organization Science*, **22**(5), 1240-53.

Julier, G (2006) From visual culture to design culture. *Design Issues*, **22**(1), 64-76.

Kimbell, L (2009) Beyond design thinking: Design-as-practice and designs-in-practice. *In*: *CRESC 5th Annual Conference*, 1-4 September 2009, University of Manchester.

Kimbell, L (2011) Rethinking design thinking: Part I. *Design and Culture*, **3**(3), 285-306.

Koskela, L, Huovila, P and Leinonen, J (2002) Design management in building construction: From theory to practice. *Journal of Construction Research*, **3**(1), 1-16.

Kvan, T (1999) *Designing Together Apart*. Unpublished PhD Thesis, Open University.

Kvan, T (2000) Collaborative design: What is it? *Automation in Construction*, **9**(4), 409-15.

Le Dantec, C A (2010) Situating design as social creation and cultural cognition. CoDesign, **6**(4), 207-24.

Luck, R (2012) 'Doing designing': On the practical analysis of design in practice. *Design Studies*, **33**(6), 521-29.

Minneman, S L (1991) *The Social Construction Of A Technical Reality: Empirical Studies Of Group Engineering Design Practice*. Unpublished PhD Thesis, Stanford University.

Nicolini, D (2012) *Practice Theory, Work, and Organization*. Oxford: Oxford University Press.

Rittel, H W and Webber, M M (1973) Dilemmas in a general theory of planning. *Policy Sciences*, **4**(2), 155-69.

Schön, D (1983) *The Reflective Practitioner*. New York, NY: Basic Books.

Simon, H A (1999) *The Sciences Of The Artificial*. Cambridge, MA: MIT Press.

Valkenburg, R C (1998) Shared understanding as a condition for team design. *Automation in Construction*, **7**(2), 111-21.

Wang, D and Oygur, U (2010) A heuristic structure for collaborative design. *The Design Journal*, **13**(3), 355-71.

Zerjav, V (2012) *Process and Project Level Issues of Design Management in the Built Environment*. Unpublished PhD Thesis, Vienna University of Technology.