DIGITAL TRANSFORMATION IN CONSTRUCTION: SYSTEMATIC LITERATURE REVIEW OF EVOLVING CONCEPTS

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ABSTRACT

Through a systematic literature review we explore the concept of digital transformation in construction. Despite the increasing prevalence of digital technologies and their profound impact on the products and production of the built, such a systematic and longitudinal view of the evolution to the current status of digital transformation, does not exist. The paper contributes by improving our understanding of the current status of digital technologies and their impact of the built environment. The review analyses 3,091 titles and abstracts and 79 full papers. We find that 50% of the studies of the sampled literature on digital transformation were published after 2015. The paper also presents implications of digital transformation with regards to professionals, projects and organisations. Surprisingly, although most of the reviewed sampled studies examine the impact of digital transformation at a project level, the future recommendations and proposed remedies focus on organisational and ecosystem levels. Finally, future directions and suggestions for digital transformation in construction are discussed.

KEYWORDS

Digital transformation, systematic literature review, innovation, organisations, projects, professionals

INTRODUCTION

This paper presents a Systematic Literature Review of digital transformation in construction. Despite the increasing prevalence of digital technologies and their profound impact on the products and production of the built environment (Wang, Xue, Yang, Luo, & Zhao, 2019), such a systematic and longitudinal view (Tranfield, Denyer, & Smart, 2003) of the evolution to the current status of digital transformation, does not exist. This paper addresses this gap in knowledge by presenting the results of a systematic review of relevant literature published since 1950 to present day.

The principle outcome of this study is to draw on the data collected in this review to understand better evolution of digital technologies in the built environment, and its wider implications in terms of professionals, projects, and organisations. By taking a longitudinal approach to the digital evolution experienced in construction, past knowledge is drawn on to inform the current challenges and opportunities offered by

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digital transformation. Specifically, this study answers three research questions (RQ), namely:

1. How have digital technologies been used in the built environment in the last 70 years and how has this evolved? (RQ1)

2. What are the implications of digital transformation for construction i. professionals, ii. projects and iii. organisations? (RQ2)

3. What future directions are indicated as necessary to address the opportunities and challenges of digital transformation for construction i. professionals, ii. projects and iii. organisations? (RQ3)

RESEARCH BACKGROUND

TOWARDS DIGITAL TRANSFORMATION

A range of terminology, such as digitisation, digitalisation and digital transformation, are widely used (often interchangeably) to describe processes of digital change. *Digitisation* is a largely technical term, referring to the transfer of information from analogue to binary, whereas *digitalisation* refers to the process of changing businesses to digital ventures (Gartner, 2013; Ross, 2017). Although this is a subtle difference in terms, it is significant, with digitalization embracing the wider context of 'technology in use' (Morgan, 2019; Orlikowski, 2000).

Digital transformation is typically defined as "an effort to enable existing business models by integrating advanced technologies" (Bughin, Deakin, & O'Beirne, 2019) and tends to be technology-laden as a concept. Digital technologies are highly pervasive and systemic (Egyedi & Sherif, 2008) and affect a variety of systems and processes. Kane, Phillips, Copulsky, and Andrus (2019) 'technology fallacy' report adds to our understanding of digital transformation by emphasising the business transformation needed and continuous 'digital adaptation', focusing particularly on social capital (Westerman, Bonnet, & McAfee, 2014).

On one hand, digital transformation brings a range of opportunities to generate and benefit from digital innovations. Framing the introduction of digital technologies as an innovation helps understandings of the impact of digital or technological change on businesses. Innovation refers to a new product, service or process (Abernathy & Clark, 1985). Accordingly, individual agency, informal processes, tacit knowledge and context shape the success of innovation. Traditionally innovation has been typified as either incremental – evolutionary and involving gradual minor changes – or radical – revolutionary and engaging in completely new approaches (Abernathy & Clark, 1985; Burns & Stalker, 1961).

On the other hand, digital transformation brings challenges specifically the risk of disruption. The process of disruption is described in Christensen's seminal publication, The Innovator's Dilemma (Christensen, 2013) where two main categories of disruptive and sustaining innovations are defined. Whereas sustaining technologies typically focus on growing existing technologies by enhancing their performance, through extended functionality or increased capacity, disrupting technologies affect the landscape of the whole industry, by solving a problem in an entirely new way or for a

new market segment. This dilemma explains why some firms are more successful when rolling out new technologies than others, as innovations that may be disruptive for one firm might not be for others. Drawing upon Christensen (2013), disruption is a process that is characterised by radical and rapid change and is often driven by technological innovation. Incumbent organizations who fail to respond to digital change are replaced by new entrants (Christensen, 2013) and industry architectures often change significantly (Henderson & Clark, 1990).

CONSTRUCTION AS A RESEARCH SETTING

As with other industries, construction has been undergoing a gradual but accelerating process of digital change in the last few decades. The built environment is on the verge of been disrupted by the 'digital vortex' (Bradley, Loucks, Macaulay, Noronha, & Wade, 2015). Numerous companies face disruption from the 'digital cyclone' Kane et al. (2019). Drawing upon Gann and Salter (2000), for the purposes of this study, we take the 1950s as the starting point for this process. Various digital technologies have shaped digitisation in construction, which in turn allow for digitalisation of business and project processes, moving towards the eventual digital transformation of the industry that we are currently experiencing.

Construction often imports technological innovations from other sectors (Pavitt, 1984). However, other sectors are doing better than construction in leveraging the 'digital thread' – a connected flow of data from design to production (Papadonikolaki, 2020). These innovations are also proving slow to diffuse. Given its high product and demand variability (Ballard, Koskela, Howell, & Zabelle, 2001) and temporary character, construction is notorious for adopting innovations in an ad-hoc manner and slow technology take-off (Davies & Harty, 2013). In construction, which is largely project-based (Morris, 2004), innovation is considered to have a slow uptake.

Scholars have presented frameworks which add to our understanding of innovations and its adoption in construction. Innovation is of various types for example, categorized into products, e.g. new materials, and processes e.g. novel workflows and digital technologies (Nam & Tatum, 1997). Slaughter (1998) created a framework to understand innovation in construction sector by explained that those are in order or complexity sorted from (a) incremental, (b) modular, (c) architectural, (d) system and (e) radical innovations. These are categorised depending on the changes regarding the innovation concept and how it links to other systems. Slaughter suggests that each of these innovations require a different implementation process, due to the varying levels of complexity and relevance across the construction supply chain.

Scholars have identified the profound advantages that digital innovations can have in construction. For example, in the last decade parts of the construction industry have been transformed by 'wakes' of innovation in project networks (Boland Jr, Lyytinen, & Yoo, 2007). From digital three-dimensional (3D) representations of built assets until automated design and construction processes using Building Information Modelling (BIM) – a three-dimensional data modelling approach – and various realities (Whyte, Bouchlaghem, Thorpe, & McCaffer, 2000), the construction sector has witnessed changes in technologies, work practices and knowledge across multiple communities (Boland Jr et al., 2007). Presently, BIM is considered the most representative digital technology and information aggregator in construction globally. While it promises to modernise construction, its adoption has created new challenges, particularly around

leadership, communication and collaboration. The impact of digital does not only pertain to technological aspects and operational improvements but also implicate commitment and trust (Liu, van Nederveen, & Hertogh, 2016) and affects coordination (Bryde, Broquetas, & Volm, 2013) and collaboration (Barlish & Sullivan, 2012).

Scholars and practitioners are widely agreed that the products and production of the built environment are being transformed by digital technologies: opportunities for sustaining digital innovations are being created across the lifecycle of built assets. Although the rate of digital change is currently accelerating sharply, it is profoundly important to recognise and understand the nature and outcomes created by digitalization of the built environment over time in the industry's projects and firms.

METHODOLOGY AND METHODS

RESEARCH DESIGN

Originally developed in the medical sciences to consolidate information from several sources, a Systematic Literature Review is a transparent, rigorous and detailed methodology used to support decision making (Tranfield et al., 2003). It builds theory by accumulating knowledge and evidence after analysing a large number of studies and methods, thereby increasing the consistency of the results and the conclusions (Akobeng, 2005). These instruments can produce new knowledge (Tranfield et al., 2003) or can document the state of the art (e.g. Lockett et al., 2006). This study documents the state of the art and provides a better understanding of the nature of the concept of digital in the built environment and then it attempts to produce new knowledge by revealing patterns that are useful for practitioners and researchers.

RESEARCH METHODS

Data collection

For this study, the sample consists of research papers relating to digital transformation in the built environment published since 1950 to 10 June 2018. We used two primary scientific databases to sample both journals and articles. Scopus and Web of Science (WoS) are two of the largest academic online databases.

The sampling strategy was limited to published refereed journal articles published in these two databases. Books, book chapters, conference papers and articles under review or in the process of publication were not included for different reasons. Books and book chapters are a limitation of systematic reviews. Their exclusion is not uncommon however, as they are often categorised in the gray literature (Adams, Smart, & Huff, 2017) or not considered to be subject of the robust review process journal articles go through (Clemens, Powell, McIlwaine, & Okamoto, 1995). There is also a limitation by the existing databases to sufficiently search for books in comparison to searching for articles. A list of exclusion and inclusion criteria is provided in Appendix 1. The review focused on journals explicitly devoted to the a. construction sector, b. mainstream management and business journals, and c. specialist journals devoted to technology. The sampling methods was done according to the following steps:

1. The search for articles was conducted through a combination of keywords. The keywords were broadly grouped into two categories. The first category was 'digit*' and 'ICT'. The second category included the following keywords: 'construction',

'built environment', 'physical infrastructure', 'architecture', 'engineering', 'AEC', Contract*', and 'infrastructure'. The key strings are shown in Table 1. This step returned 120,927 articles in Scopus and 61,551 in WoS.

2. The returned articles were then filtered according to three filters: English language, peer reviewed journals, and research domain. We kept papers from the following domains: Scopus: Social sciences, Business, Decision sciences; WoS: Operations Research Management Science, Urban Studies, Transportation, Business Economics, Sociology, Construction Building Technology, Architecture. The returned articles for Scopus were 1,510 and for WoS 1,741.

3. We then consolidated the articles and ended up with 3,091 articles. These were inserted into Mendeley software. The articles were then evenly split among four researchers. In this step, the team screened the article titles and abstracts and applied three criteria to limit the number of papers for review. Items were excluded if a. the journal title does not fall in the either of the following: built environment, mainstream business and management domain, specialist journals devoted to technology. b. the title of the article and abstract does not explicitly state the context of the study being the built environment c. articles focusing explicitly on a technical issue and ignore implications in terms of agents, projects or firms. The researchers moved any excluded articles in designated folders according to the exclusion filter that was applied. Furthermore, the team introduced a quality assurance process in this step. Once each member completed the screening process, they were appointed to review the exclusion folders of another member to ensure an article was excluded within reason. In addition, the researchers checked for duplicated articles and excluded them accordingly. This step returned 155 articles.

4. The 155 articles were then inserted into MS Excel. Once again, the articles were evenly split among the four researchers. This time the team reviewed the articles from start to end and applied the inclusion criteria (see Appendix 1). Quality assurance measures were also taken in this step, and similarly to the previous step, each member reviewed the excluded articles of another member. For example, studies that were simply reporting technical advancements and did not relate to implications to professionals, projects and organisations were excluded. This step returned 79 articles, which is the core of this qualitative synthesis.

Table 1: Key strings for searching papers in Scopus and Web of Science

Database	Key string
Scopus	(TITLE-ABS-KEY (digit*) AND TITLE-ABS-KEY (construction) OR TITLE-ABS-KEY (infrastructure) OR TITLE-ABS-KEY ("built environment") OR TITLE-ABS-KEY (architecture) OR TITLE-ABS-KEY (contract*) OR TITLE-ABS-KEY (aec)) AND DOCTYPE (ar) AND (LIMIT-TO (SUBJAREA , "SOCI") OR LIMIT-TO (SUBJAREA , "BUSI") OR LIMIT-TO (SUBJAREA , "DECI")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (SRCTYPE , "j")) AND (EXCLUDE (SUBJAREA , "COMP") OR EXCLUDE (SUBJAREA , "ARTS") OR EXCLUDE (SUBJAREA , "MATH") OR EXCLUDE (SUBJAREA , "EART") OR EXCLUDE (SUBJAREA , "MEDI") OR EXCLUDE (SUBJAREA , "AGRI") OR EXCLUDE (SUBJAREA , "HEAL") OR EXCLUDE (SUBJAREA , "PHYS") OR EXCLUDE (SUBJAREA ,

	"CHEM") OR EXCLUDE (SUBJAREA , "BIOC") OR EXCLUDE (SUBJAREA , "CENG") OR EXCLUDE (SUBJAREA , "MATE") OR EXCLUDE (SUBJAREA , "NEUR") OR EXCLUDE (SUBJAREA , "NURS") OR EXCLUDE (SUBJAREA , "MULT") OR EXCLUDE (SUBJAREA , "PHAR") OR EXCLUDE (SUBJAREA , "VETE") OR EXCLUDE (SUBJAREA , "DENT")) AND (EXCLUDE (SUBJAREA , "ENGI") OR EXCLUDE (SUBJAREA , "ENVI") OR EXCLUDE (SUBJAREA , "ECON") OR EXCLUDE (SUBJAREA , "ENER") OR EXCLUDE (SUBJAREA , "PSYC"))
Web of Science	You searched for: TOPIC: (digit*) AND TOPIC: (construction OR infrastructure OR "built environment" or "architecture" or "engineering" or "contract*" or "AEC") Refined by: DOCUMENT TYPES: (ARTICLE) AND RESEARCH AREAS: (OPERATIONS RESEARCH MANAGEMENT SCIENCE OR URBAN STUDIES OR TRANSPORTATION OR BUSINESS ECONOMICS OR SOCIOLOGY OR CONSTRUCTION BUILDING TECHNOLOGY OR ARCHITECTURE) AND LANGUAGES: (ENGLISH) Refined by: DOCUMENT TYPES: (ARTICLE OR BOOK CHAPTER) AND RESEARCH AREAS: (ARCHITECTURE OR BUSINESS ECONOMICS OR CONSTRUCTION BUILDING TECHNOLOGY OR SOCIAL SCIENCES OTHER TOPICS OR TRANSPORTATION OR URBAN STUDIES OR OPERATIONS RESEARCH MANAGEMENT SCIENCE) AND DOCUMENT TYPES: (ARTICLE OR BOOK CHAPTER) AND LANGUAGES: (ENGLISH)

Data analysis

Theoretical thematic analysis (Braun & Clarke, 2006) was the selected method to analyse the 79 articles. Data analysis focused on the three objects of enquiry as outlined in the Introduction section. The articles were reviewed using a theoretical or deductive 'top down' way as described by Boyatzis (1998). According to Braun and Clarke (2013, p. 84), this theoretical thematic analysis "tends to be driven by the researcher's theoretical or analytic interest in the area and is thus more explicitly driven".

This approach fits well with our overall methodology, because the team was interested in coding according to the three specific research questions. For example, the team coded data in the extraction form detailing the type of technology used and discussed in the article. The team would then categorise each extract as per Slaughter (1998) framework. For RQ2, the team extracted data outlining the implications stated in the articles in terms of individuals, projects or firms. Similarly, for RQ3, data were consolidated in terms of individuals, projects or firms. The coding of data was done according to the following steps:

1. The 79 articles were evenly split among the four researchers. An extraction form was prepared in MS Excel (Table 2). Each researcher read their batch to become familiar with the data and extracted relevant information in the extraction form. The examination was based on the full text. Descriptive data were extracted (list of authors, title, journal title) and data that responded to the three research questions of our study.

2. Initial codes were generated by each member. The codes aimed at capturing anything that seemed relevant to the three research questions. Open coding was used in this step.

3. The extracts of each article are classified at this point in relation to Slaughter's framework and whether the focus has been at the individual, project or firm. A master file is created, and the team identifies preliminary themes. For RQ1, descriptive statistical analysis is used to flesh out insights regarding Slaughter's framework and the type of technology mentioned in the articles. For RQ2 and RQ3, subsequent themes are generated under each of the three initial lenses (individual, project, firm).

4. The preliminary themes from Step 3 are reviewed by the team in this step. The team assessed each theme using the following criteria: the themes represent the entire dataset; the themes do not overlap; the themes make sense in relation to the research question; and whether there are any other themes within the data.

5. In this step, the themes were finalised. According to Maguire and Delahunt (2017, p. 33511), the following questions were posed in this step: "What is the theme saying? If there are subthemes, how do they interact and relate to the main theme? How do the themes relate to each other?". Answering these questions helped the team illustrate the relationships between themes and develop the narrative for each research question.

6. In the final step, the team reported the findings in relation to three research questions.

Table 2: Extraction form

Category	Code	Description
Demographics	Authors	List of authors
	Title	Title of article
	Year	Year of publication
Sample	Journal	Title of journal in which the article was published
	Empirical setting	Country from which the data were collected
	Construction segment	Industry from which the data were collected
Research design	Paradigm	Positivism, social construction, advocacy
	Research design	qualitative, quantitative, mixed methods
	Method	Case study, semi-structured interviews
Findings	Type of technology	Type of technology clearly stated
	Type of Innovation	Categorization as per Slaughter's (1998) categorisation
	Outcomes/effects	Categorization as per agents/professionals, projects, organisations
	Future research	Areas for future research

DATA PRESENTATION

EVOLUTION OF DIGITAL TECHNOLOGIES IN THE BUILT ENVIRONMENT

To respond to the first research question, the literature analysed was of qualitative, quantitative, mixed methods and conceptual studies. Most of the studies were qualitative in terms of data collection and data analysis (n=38). There was also a non-negligent set of conceptual studies that were building propositions for future research

based on desk reviews (n=14). The literature review sample was mainly following a constructivist research philosophy (n=28) and there were less studies holding a positivist approach (n=13). The prevalent research methods were typically case studies where data were either semi-structured interviews or numerical data from analyses of projects.

The empirical setting of the literature sample analysed was typically around the USA, Australia and Southeast Asia there were also few studies originating from the Scandinavian countries and the Netherlands. The construction segment that most studies addressed was the Architecture Engineering and Construction (AEC) industry and there were less studies coming from the building domain, urban development site, transportation and real estate sectors. Most studies were published in Automation in Construction, the Journal of Construction Engineering and Management as well as the Building Research and Information journal.

Surprisingly, 50% of the studies of the sampled literature on digital transformation were published after 2015. This means that in the last 5 years the scholarly production of research on digital transformation has quadrupled, although the topic was investigated sporadically from the 2000s. Figure 1 illustrates how the analysed literature is spread in terms of publication year. After the 2000 a steady increase in research on Computer-Aided Design (CAD), digital prototyping, internet applications, algorithms for generating design and generally Information Communication Technologies (ICT). After 2009 there was a sharp increase in research on commercial applications of BIM that is still dominant as well as more research and studies more on robotics, big data analytics, cloud computing and applications for developing smart cities. Figure 2 illustrates the frequency of the various digital innovations across the data sample.
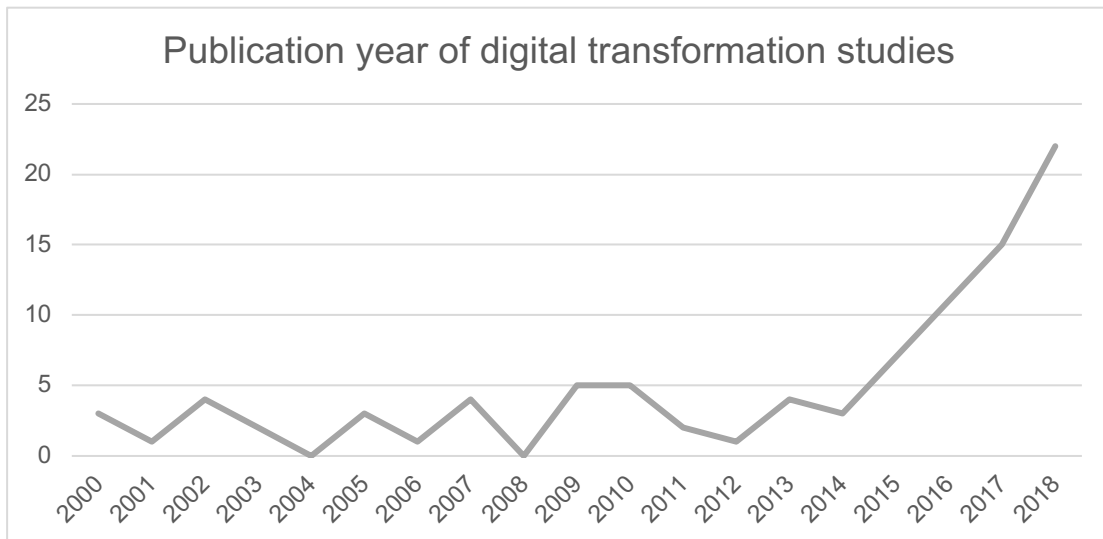

Figure 1: Publication year of sampled studies on digital transformation.
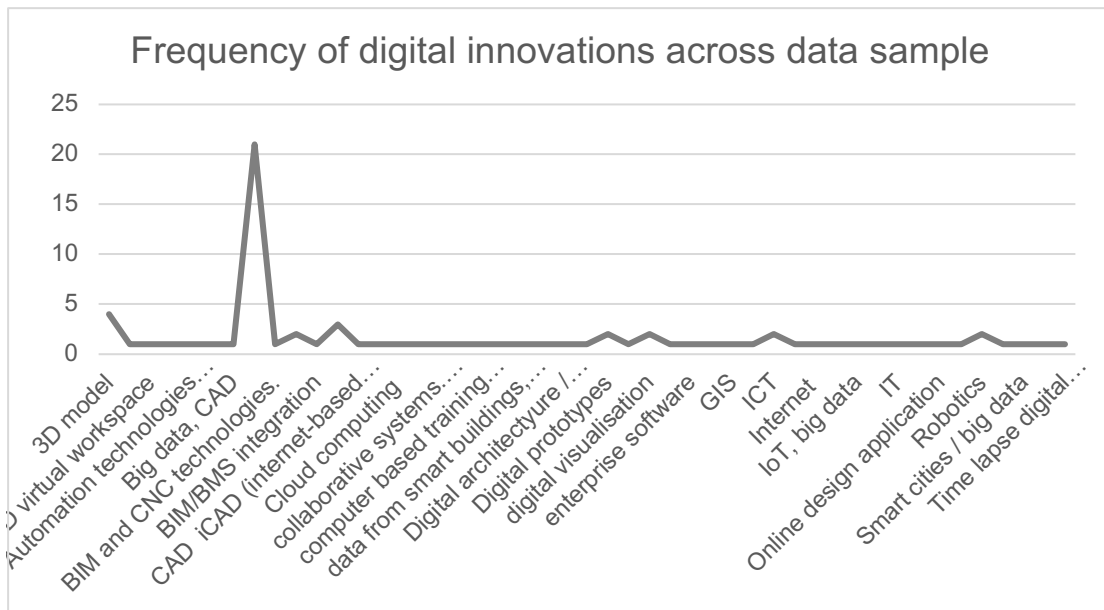
Figure 2: Frequency of digital innovations across the data sample (ordered alphabetically).

IMPLICATIONS OF DIGITAL TRANSFORMATION

The analysed literature sample returned a variety of implications of digital technologies across professionals, organisations, projects and wider industry. In particular, most of the implications were discovered in the area of projects that are the signature organisational form through which construction sector is organised. This was followed by implications to professionals and different agents across the construction supply chain and less focusing on organisations and how these are evolving to address digital transformation. Figure 3 illustrates how the reviewed studies addressed to various aspects of construction ecosystem.

Figure 3: Categorisation of implication areas of literature on digital transformation.

The data discussed the outcomes and effects of digital transformation across various units of the built environment. First, there were opportunities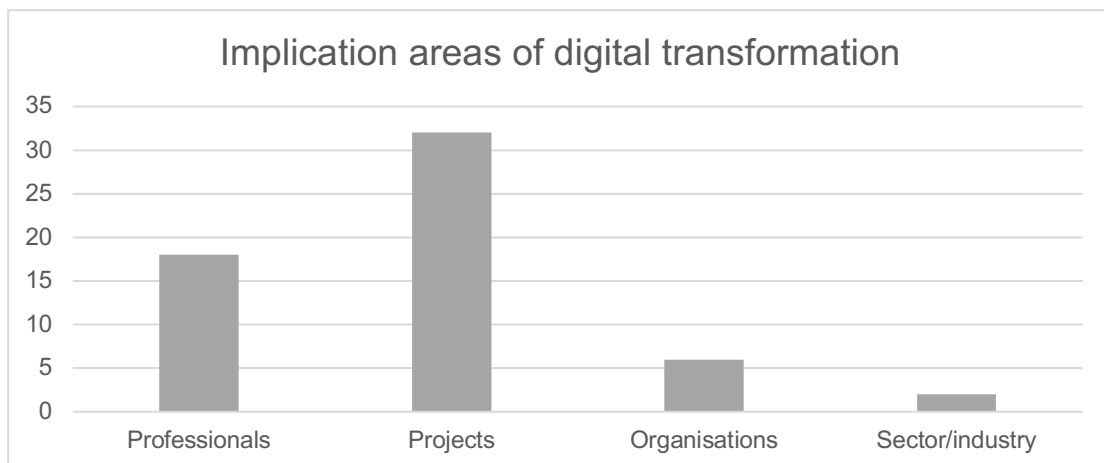 for knowledge externalities across sectors such as computer science (Koutamanis, 2000) that bring further implications for the design and engineering professions and their pedagogy (Baker & Ward, 2002). Second, most of the data showed a significant impact of digital innovations on projects, project teams (El-Tayeh & Gil, 2007) and construction processes to create better practices (Boland Jr et al., 2007). Third, there were a few references that digital creates shifts in industry architectures to develop new organizational logics in firms (Yoo, Henfridsson, & Lyytinen, 2010) and change their business models and strategies (Woodard, Ramasubbu, Tschang, & Sambamurthy, 2013).

The literature discussed various digital innovation that were mapped onto the Slaughter (1998) model of construction innovations. Most of the studies (n=21) were of systemic innovation type that is more complex and requires higher degree of coordination across projects teams for implementation. In particular, such innovations require a greater commitment at the conceptual design stage and coordination across all project team members. At the same time, systemic innovations require special resources to integrate a set of innovations as well as supervision at top engineering and management levels with demonstrable competences of technical and system competences. Figure 4 illustrates how the digital innovations reviewed as part of the literature review data map across Slaughter (1998) model of construction innovations.
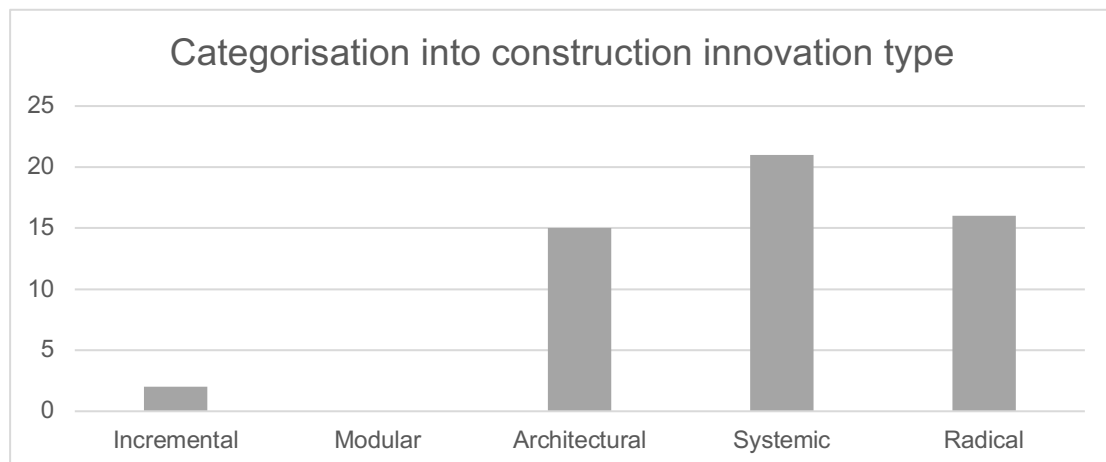
Figure 4: Mapping of digital innovations across the Slaughter (1998) model of construction innovations.

FUTURE DIRECTIONS AND SUGGESTIONS FOR DIGITAL TRANSFORMATION

The analysis also focused on future research directions, forward looking, trying to address future problems and prepare the industry for digital transformation. Indicative findings about future directions show that there is an increasing interest to the operation of built assets as well as understanding the role of clients and owners/operators in digital transformation. Most visions referred to smart cities and how digital transformation can incrementally support a vision for smart, connected environments at a city level.

At an organisational level, various studies looked at how the performance of firms can be improved by digital transformation at the same time attempting to reduce costs and expenses of investment in those digital innovations. This also describes different implications for professionalism as digitalisation essentially created new practices, new roles and requires amended processes within organisations. Understanding, defining and improving relations among professionals, organisations and wider industry stakeholders is a key consideration for future research.

Surprisingly, although most of the implications of digital were found at a project level (see Figure 2), future research was not at a project level but instead at more organisational and an industry transformation level. Future research direction would look at relationships between urban governance and digital infrastructure as well as looking at how digitalisation can streamline the building permit processes (Tilson, Lyytinen, & Sørensen, 2010). Naturally, this implies that there is a lack of digital capabilities from public sector (Neff, Fiore-Silfvast, & Dossick, 2010) that is a further avenue for research especially since local government across various countries develop standards and mandates and are looking into ways to incentivise the industry to develop capabilities for digital delivery (Lobo & Whyte, 2017). Figure 5 presents a word cloud of main concepts included in the future directions of the analysed literature sample.

Figure 5: Concepts of future directions of digital transformation literature sample.

DISCUSSION AND CONCLUSIONS

The emerging findings from this search make first a contribution to knowledge by organising and presenting a wealth of data from our systematic literature review. Specifically, the data showed an accelerated pace of relevant studies around 2000 with marked interest in design and design/construction interfaces using increasingly international data sets. A proliferation of digital technologies was discussed in these more recent papers. Main digital technologies discussed were: BIM, augmented reality,

virtual reality, Internet of Things (IoT), cloud computing and integrated decision systems and the digital as a concept evolves towards more connected and holistic considerations (RQ1).

Second, the study shows how increasingly these innovations were aligned with the 'systemic' innovation description by Slaughter (1998). This is in line with the definition of digital transformation as affecting systemic change. The data indicated a growing researcher interest in the impact of digital technologies on projects, as opposed to other levels of analysis in the AEC industry, such as firms, individuals and the industry. Arguably, the conclusion could be drawn from this that the effects of digital are more profound in the project arena than elsewhere.

Third, one unexpected finding was the mismatch between implications and proposed remedies across the analysed studies. Surprisingly, further research directions of the analysed research focused more on ecosystems and organisations (RQ3) and less on project management and project-level considerations, which was a dominant logic in presenting the effects of digital technologies (RQ2). This mismatch shows an interest to look outside the tight boundaries of project-based considerations and traditional governance models and business models in the built environment.

Lastly, our findings also indicate how individuals need to develop 'soft' skills' such as collaboration, flexibility, integration, teamwork to work across traditional silos, experimentation, risk taking, and avoiding overreliance on commercial software. Similarly, projects start incorporating more whole-life considerations and firms change their business models and strategy and focus on leadership to develop resilience and adaptability.

Hence, performing a 'digital shift' very much requires a 'cultural shift' by adjusting leadership, communication and collaboration models. The above implications suggest the need for practice and academic to adopt a holistic approach towards digitalisation and a socio-technical view use (Orlikowski, 2000). Similarly, a higher alignment across supply chains in needed to address the challenges of systemic innovations that mobilise further socio-political and organisational implications, beyond the confined boundaries of projects. Digital transformation activates the need for organisational and ecosystem considerations to address the threat of digital divide (Van Dijk, 2006) and better support diffusion if digital innovations across the sector.

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APPENDIX 1. LIST OF EXCLUSION AND INCLUSION CRITERIA

Exclusion criteria:

1. The article is part of conference proceedings

2. There is no abstract available

3. The article is in not in English

4. The Subject area is not Engineering, Construction, Business, Management and accounting, Organisation science, Decision sciences

Inclusion criteria:

1. Study has to be published as an original article

2. Concept of digital and derivatives has to be essential for the intervention and therefore explicitly mentioned

3. Papers focusing only on technological aspects (i.e. electrical engineering) will be excluded

4. Studies have to be based on empirical data collection or conceptual papers.

5. Literature review papers are excluded