Investigating the Skills and Knowledge Requirements for IOT implementation in Construction

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Abstract

In line with the exponential rate of advancement in information technologies within industries globally, the construction industry has stepped out of the conventional technologies to embrace smart technologies. Internet of Things (IoT) is one such technological advancement in construction although the improvement is taking place at a glacial pace. Internet of Things (IoT) allows stakeholders in construction to collect real-time data from a construction site and transform them into useful information for better insights. It enables construction industry to become smarter, safer and more efficient. Moreover, for a construction industry increasingly looking at boosting productivity, maximizing efficiencies and making the most whole-life value through added intelligence, it's not too difficult to see the demanding potential of IoT technologies to offer the latter expectations. However, lack of skills and knowledge to match this digital demand has been a prominent issue in construction. Although this skill gap is often dominated by the diminishing supply of manual labour, the lack of digital and non-digital skills is an equally pressing concern. Upskilling existing workforce is a simple yet effective way to combat this skills gap. This paper therefore investigates the Skills and Knowledge Requirements to implement IOT in Construction. An empirical investigation conducted in construction industry, United Kingdom enabled the envisaging of the skill-knowledge requirement not only present but also for future.

Keywords
Construction Industry, Internet of Things, Knowledge, Skills.

1. Introduction
1.1 Background and rationale

The radical changes discharged by the rise of global digital economy are making remarkably profound implications for the construction industry urging the requirement for a major industry-wide transformation. To keep up the pace in line with this digital transformation, firms in construction industry are starting to prepare themselves by making attempts to streamline their organisations as well as the projects with digital solutions, such as 6D BIM (Chu *et al.* 2018), 3D printing (Karji *et al.* 2017), robotics, Big Data Analytics (Eriksson *et al.* 2017), Internet of Things and robotics (Jesse 2018). A few had succeeded in the pilot phase itself while majority of firms in construction industry are striving to step out of the conventional construction methods as well as the conventional business processes (Perera *et al.* 2017). Site and office workers are urged to adopt yet more new technologies before abandoning them and returning to their old ways of working. This is because the transformation involved more of a cultural change than a technological change, combined with the industry and its deeply rooted traditions are making it slow and strenuous (Perera *et al.* 2017). As a result of this slow-moving process, projects are hitting with delays and running over budget as frequently as before, and productivity had barely budged upward. The situation remains too common in the construction industry, which is long being labelled to be one of the least digitised compared to other major industry sectors (HM Government 2015).

The barriers that hamper the ability to be a digitalised sector demonstrates an interconnectedness with long prevailing issues in construction inter alia; fragmentation, industry being inhomogeneous (lack of replication), shortage of skilled professionals and decentralisation (HM Government 2013). Construction projects are typically fragmented along the supply chain, with specialists generally operating in one or a small number of disciplines and the supply chain involve multiple layers of stakeholders working in a less collaborative environment (Papadonikolaki *et al.* 2017). Thus, implementing digital solutions across a poorly collaborated environment makes it difficult, given the short-term and often adversarial nature of construction contracts. Moreover, the construction projects that are unique and seldom repeated necessitate bespoke design-delivery approaches. This uniqueness and lack of replication also makes it difficult to introduce changes across projects, as full-scale transformation is required. Decentralisation is another factor that hampers change implementation across an organisation. Especially in large organisations that are highly federated in nature tend to operate as separate business units and divisions following their own processes rather than standardised set of rules coming from central authority (De Carvalho and Rabechini Junior 2015). This fact is quite common in individual sites that take place far from their company head office. These sites are hardly conducive to train workers with innovative ways of working using digital technologies. Shortage of skilled professionals and especially digital-aware professionals is another issue long prevailing in the industry. The construction industry has traditionally looked at training employees with compliance as the primary motivator. With digital technology now being pervasive in most other industries, the construction industry sees the greater need to adapt accordingly in order to avoid being left behind. The major disadvantage of not having a digitally literate workforce involves losing the competitive advantage within the market space. This leads to inefficiency in the way the industry operates and reduces its overall competitiveness (HM Government 2013). Competitors with digital technological expertise may enter the market and potentially squeeze out those more-traditional contractors and suppliers. Skills shortages among trade and professional occupations are inhibiting technology deployment and innovation (HM Government 2013). These characteristics of the construction industry are making it difficult for organisations to adopt digital solutions which can be applied to multiple projects across organisations.

Although the difficulties are legitimate, the time has now arrived to keep up with the transformation in the most feasible way. Yet, an increasing number of firms in construction are seen as overcoming these challenges to transform projects or even business units digitally (Pan 2018). As purported by Digital Built Britain (HM Government 2015), despite differing conditions, transformations in construction firms must have five strategic domains where 'bridging the skill gap for technology deployment and innovation' is one of them (HM Government 2015), from which all engineering and construction firms embarking on similar transformations may learn. The construction industry faces a pressing need for a capable workforce that can deliver transformational change in digital technology adoption, implementation as well as exploitation in the next decade. As the wider economy emerges from recession, construction firms must be able to recruit, retain and develop skilled employees in sufficient numbers to meet the increasing demand for construction. Moreover, since the industry is targeting fully embracing digital economy (HM Government 2013), it will need to mobilise the competencies and capabilities of workforce in order to effectively apply technology in the built environment. Digital design techniques and technical know-how are already creating an imperative for this, but most importantly, the next decade will also demand multi-disciplinary skills that enable integration right through the supply chain. This would also entail that not only the technical know- hard skills but also the soft skills are on offer for digitalised industry. The construction Industry and UK Government is working with skills bodies to ensure that capability and capacity issues in construction are addressed in a strategic manner (HM Government 2015). One of the main strategic concerns of their commitment is 'better determination of future capability/ competency needs for a digitalised industry'. The digitally built industry towards fourth industrial revolution aims at taking on-board number of innovative digital technologies. Some of the emerging fields in the fourth industrial revolution include Internet of Things (IoT), robotics, machine learning, artificial intelligence (AI), and nanotechnology (Reinhard *et al.* 2016). Notwithstanding, 'internet of things' is at its core (Reinhard *et al.* 2016). IOT is promising a dramatic transformation in the construction industry especially by creating new opportunities for construction projects to collect data and accurately analyse them.

Engineering and construction companies plan to invest 5% of annual revenue in digital operations solutions per annum over the next five years and they are setting themselves ambitious targets for the level of digitisation and integration that can be achieved (Reinhard *et al.* 2016).The UK Department for Business Innovation and Skills (BIS) estimates that the big data and Internet of things trend will affect all industry sectors over time (HM Government 2015). Over the next decade, BIM related technologies will combine with the internet of things (providing sensors and other information), advanced data analytics and the digital economy to enable planning new infrastructure more effectively, build it at lower cost and operate and maintain it more efficiently (HM Government 2015). It is also estimated that the use of Internet of Things has the potential in securing 20% savings on CAPEX to deliver a digital construction economy. This has been achieved in parallel with the emergence of the Smart Cities Agenda, which identifies a global market of around £400B by 2020 for services related to smart systems for transport, energy, health care, water and waste (BIS 2013). Furthermore, the Information Economy strategy set by the UK government also encourage the development of the technology market, to use High Performance Computing (HPC), complex analysis and the Internet of Things (IoT) in the form of automated sensors and actuators to automate processes. Above all, "Digital Built Britain" (DBB), will encompass the cross sector collaboration and thinking described above whilst taking the opportunity to rethink how we procure, deliver and operate our built environment going forward to ensure we meet our fiscal, functional, sustainability and growth objectives (HM Government 2015).

Since IoT is considered as a disruptive emerging technology, one of the determinant pillars of digitalisation influenced by fourth industrial revolution, yet an extremely important technology promising productivity improvement and operational efficiencies, this paper empirically investigates the skills and Knowledge required implementing IOT in construction. The goal is to synthesise the perceptions of industry professionals to understand the skill/ knowledge requirement for IOT implementation. A structured questionnaire survey was conducted in order to identify the level of importance in the skills identified from the existing literature. Building on this knowledge, the paper will provide a recommendation for the IoT adoption and implementation guide for practitioners and directions for future research.

2. Review of relevant literature

2.1 IOT in construction

The construction industry in general is setting an open and user-driven innovation platform to demonstrate the value of future internet enabling service in line with the exponential rate of advancement in information technologies, technological applications and digital-aware devices globally (Woodhead *et al.* 2018). As rationalised in the introduction, firms in the industry have been embracing the use of advanced ICT-enabled built environment such as Internet of Things (IoT) which has been considered one of the determinant pillar of ICTs as well as the fourth industrial revolution (4IR), which has been defined as a large heterogeneous network of built environment activities based on the capability to exchange data and integrate them with physical and virtual "things" (Jia *et al.* 2019).

Internet of Things (IoT) refers to a system of connected physical objects via the internet (Marjani *et al.* 2017). The 'thing' in IoT can refer to a person or any device which is assigned through an IP address (Garyaev and Garyaeva 2019). Papadonikolaki *et al.* (2017) signifies the problems within construction industry that could be addressed by the use of IoT. As mentioned in the 'background to this study', industry fragmentation, poor performance, poor productivity, waste generation, delays and budget overrun are some of them (Pan 2018). To this end, IoT potentially supports efficiently managing the Industry's problems and complexities with real time controlling and promotes trust between players in the supply chain (Teizer *et al.* 2017). Some of the applications of IoT in construction include Smart Cities & the Sharing Economy (Ibba *et al.* 2017); Smart Homes (Jia *et al.* 2019); Intelligent Transport and logistics (Dorri *et al.* 2017); Construction worker health and safety (Akhavian *et al.* 2015); Facility Management (Jia *et al.* 2019) and Efficient resource management (H. Gupta *et al.* 2017). In terms of the extent of application, a survey conducted by PWC, UK states 30% of companies in Architecture, Engineering and Construction sector in UK have already initiated or planned to initiate technologies related to IoT especially fuelled by Industry 4.0 scheme (Reinhard et al. 2016). Moreover, engineering and construction companies plan to invest 5% of annual revenue in digital operations solutions per annum over the next five years. On one hand, IoT provide more efficient services solutions to clients; while on the other hand, intelligent revitalised IoT applications enhance the efficiency in operational processes from the production perspective (Dave *et al.* 2018). Despite the benefits and advancement brought by IoT to many industries including construction industry, some challenges and drawbacks remain unresolved. Lack of IoT specific experts/ professions and Lack of skills, knowledge and training is one such major barrier as identified by many of the authors (Jesse 2018).

2.2 IOT skills/ knowledge dimensions

Reinhard *et al.* (2016) in their study for industry 4.0 in construction conducted a number of interviews with engineering and construction companies and explored the prevailing challenges to execute industry 4.0 in construction. The findings revealed that the biggest challenge revolve around internal issues include culture, organisation, leadership and skills, rather than external issues such as standards set by public bodies and data security- privacy. The absence of a digital culture and insufficient training was identified as the single biggest challenge by more engineering and construction companies than any other. Moreover, lack of skills and training for digital technologies has also been acknowledged by 2016-2020 government construction strategy (Infrastructure and Projects Authority 2016). Thus, the need to conduct investigations on the skills/ knowledge requirements for current and future is vital.

There has been an emerging interest of construction management literature for the lack of studies that analyse the need for skills/ knowledge for IOT implementation from the perspective of firms; and the emerging need to find level of importance in respect to the time line (now and the future) (Pan 2018).Therefore, from a practical point of view, it is worthwhile investigating how the implementation of IoT in firms within construction industry required to be reshaped in order to cater the skill and knowledge demand; which has also been a cause for the change in working patterns and has effected firms' competitive advantage (WEF 2016). Based on the observations on the current extent of IoT adoption, benefits and barriers to IoT implementation, following research questions have been set up for investigation:

RQ1. What are the most important skills/ knowledge dimensions CURRENTLY required to implement IoT in construction?
RQ2. What are the most important skills/ knowledge dimensions required to implement IoT in construction in the FUTURE (in next five years)?

In response to the above two 'Research Questions' the researchers performed a systematic review of literature to gather a list of skills/ knowledge dimensions. The literature suggests a variety of skills/knowledge areas ranging from technical skills to managerial skills. SAS in their survey for skills and resources that are most useful in their IoT projects identified being able to manage those bought-in skills and the ability to work collaboratively with external consultant as the most important skill in IOT adoption in to an organisation (CEBR 2016). The next three most important skills as identified by SAS were: process automation, engineering skills to address sensor performance, data reliability and adapting people tasks to the new technology. Their conclusion was that, the skills required to be represented both technology and also cooperation (CEBR 2016). De Carvalho and Rabechini Junior (2015) and Zuo *et al.* (2018) highlights the importance of distinguishing soft and hard skills in general construction management which helps the project managers to understand not only the technicality, but also the importance of solving people-related issues among various stakeholders so that the mutual understanding can be achieved. Once a full list of skills/ knowledge is identified they were then synthesized to come up with a finite list combining both hard and soft skills. The Table-1 presents this set of skills brought forward as inputs for the questionnaire survey described in 'Methodology' section.

Table 1. The skills/knowledge that may be required in present and future job role, in managing implementation of IOT (Internet of Things)

The skills/knowledge dimensions for IOT (Internet of Things)	**Code used in SPSS Analysis**
Leadership (i.e. leading and guiding others through the overall process of implementing/exploiting interconnected IOT systems)	SKIOTIMP1
Communication- oral/written (i.e. communicating overall managerial goals of IOT systems)	SKIOTIMP2
Negotiation (i.e. negotiating with business partners/ clients/ supply chain members for maximizing the delivery value as well as for business development)	SKIOTIMP3
Motivation (i.e. encouraging employees to use and share IOT tools and processes productively and effectively)	SKIOTIMP4
Team Work (i.e. managing collaborative teams involved in the delivery of IOT projects including steering committee recruitment and delegation of authority according to each individual's competencies)	SKIOTIMP5
Decision Making (i.e. making the right decisions to achieve organisational or managerial objectives)	SKIOTIMP6
Strategic Planning (i.e. Identify strategic objectives and implement strategies)	SKIOTIMP7

Partnership and Alliancing (i.e. initiating partnerships and alliances with other organisations based on IOT deliverables for business development)	SKIOTIMP8
Finance Accounting and Budgeting (i.e. planning, allocating, monitoring and controlling the costs associated with IOT implementation/ exploitation)	SKIOTIMP9
Marketing (i.e. promoting organisation's IOT capability to its clients and business partners, carry out research on the market position, absorptive capacity and appetite for IOT deliverables)	SKIOTIMP10
Tendering and Procurement (i.e. facilitating and steering the procurement of IOT products and services including managing the contractual obligations underlying collaborative IOT Projects).	SKIOTIMP11
Risk Management (i.e. managing the risks associated with using IOT tools and interconnected systems)	SKIOTIMP12
Quality Management (i.e. establishing, managing and controlling the quality of IOT systems	SKIOTIMP13
Performance Management (i.e. evaluating the organisational IOT capability against a benchmark and Business Intelligence to gain insights though monitored IOT data)	SKIOTIMP14
Operational Management (i.e. wireless protocols like Bluetooth/3G/4G low energy connections and automation of IoT hardware devices with sensor systems and intelligence software- automated room control systems, smart building)	SKIOTIMP15
Technological infrastructure Management (i.e. installing, managing and maintaining general IT infrastructure, including cloud platform connectivity with specific software and hardware equipment requirements)	SKIOTIMP16
Legislation Management (i.e. understanding the legal requirements of IOT protocols- regulations, privacy, security and copyright of IoT data)	SKIOTIMP17
Innovation Management (i.e. support and facilitate experimenting new beneficial uses of the innovation processes for continuous improvement and change management)	SKIOTIMP18
Supply Chain Management (i.e. design, plan, execute, control, and monitor supply chain activities related to IOT processes to provide best value)	SKIOTIMP19
Information Management (i.e. acquisition of information from varied sources in varied formats to storing, processing and distribution of them)	SKIOTIMP20

The next section explains the process of how the list of skills/knowledge dimensions was employed to answer the two research questions.

3. Methodology

The 'level of importance' for the skills/ knowledge dimensions required for IoT implementation has been investigated by a structured web-based questionnaire survey. Questionnaire survey approach is appropriate when researching a "what" questions about a contemporary set of items, over which the investigator has some form of control (Creswell 2014). The researcher holds some of control because the constituents presented in the questionnaire are pre-determined and selected via a systematic review of literature. This simply means that the skills/ knowledge dimensions inquired in the questionnaire are derived from the recent peer reviewed publications in academia. In this case, an explanative approach has been adopted and the study has been based on the unit of analysis of 'construction firm' (Creswell 2002). Through the web-based questionnaire, managers were asked the current and future relative importance of skills-knowledge dimensions.

The respondents to the questionnaire were chosen through a non-random purposive sampling effort. The respondents involved practitioners occupying managerial roles at various levels in the UK construction companies using the IoT in their operations. The analysis follows a two-fold strategy. First, the 'level of importance' relating to each IoT skill/ knowledge was questioned for the current scenario. A 4-point Likert scale was employed in the questionnaire with a scale from 1 to 4 representing the level of importance (1- very high, 2- high, 3- low and 4- very low) of the skills and knowledge that are reported to be key for IoT implementation by the literature. The second part of the analysis explored level of importance in same skills and knowledge considering the needs of next five years(future). Thus, the two fold strategy not only reveals the skills and knowledge required to meet the current IoT needs, but also reveals the practitioners' view about where these skills/ knowledge dimensions are likely to be in next five years. This would ultimately answer the two research questions.

4. Data Analysis, Findings and Discussion

160 questionnaire forms were distributed and 52 usable responses were received which gives an average of 32.5% response rate. This response rate is well above the acceptable range (20-25%) as purported by Root and Blismas (2003) explaining the general attitude within the construction management community.

In order to check the normality of variable list, 'descriptives' of each variable were studied first. These 'descriptives' include normality tests such as Shapiro-Wilk and Kolmogorov-Smirnova tests. The percentage trimmed mean for all skills/ knowledge variables was within the range of 3%-5%. Since a significant difference cannot be seen between collective original mean (3.11) and collective trimmed mean (3.12), no further investigation is required for these data points (Pallant 2011). Even though the data set is NOT 'perfectly normal' (the values for latter tests are not equal to '0'), it neither shows significance 'peakedness', nor a far deviation from the symmetric distribution. The situation remains same for all variables of inquiry presented in this paper. It is then imperative to check the internal consistency/ reliability of the data. The reliability of the questionnaire was tested using Cronbach's alpha analysis which is the most common measure of internal consistency ("reliability"). Results of the reliability test show that group Cronbach's alpha value is 0.788 and 0.684 for NOW and FUTURE skill/knowledge variables respectively. This remarks near high level of consistency between the variables presented.

Having known the reliability and normality of data set, it is also worthwhile to check whether the difference between certain groups is statistically significant. Few statistical hypothesis tests were performed in this regard. The groups were considered on the basis of individual job role, JOBR (strategic level, tactical level, operational level) and organization size- ORGSIZ (Micro, Small, Medium and Large). First, in order to compare the perceptions for the level of importance in skills and knowledge for IOT implementation between the senior, middle and lower level management (JOBR), a non-parametric test that indicates the statistical significance between the differences in groups- Kruskal-Wallis H test was utilised. This test allows comparing the scores of some continuous variable for three or more groups. The reason why Kruskal-Wallis was employed against Mann-Whitney U test is because Mann-Whitney U test only allows comparing two groups. Since all variables of inquiry in comparing groups have more than two groups, Kruskal-Wallis H test is the most suitable test. Table 2 presents these data for both future and current variables.

The hypotheses established for this analysis are as presented below:
$HO_{(JOBR)}$: the mean ranks of the three groups responded for current AND future level of importance for IOT implementation are equal.
$HA_{(JOBR)}$: the mean ranks of the three groups responded for current AND future level of importance for IOT implementation are not equal.

$HO_{(ORGIZ)}$: the mean ranks of the four groups responded for current AND future level of importance for IOT implementation are equal.
$HA_{(ORGIZ)}$: the mean ranks of the four groups responded for current AND future level of importance for IOT implementation are not equal.

The results interpreted in Table 2 shows only two variables with significant differences influenced by organisation size. These include [SKIOTIMPNOW18 (Innovation Management) ($H = 10.548$, $p = 0.014$, $df = 3$)] and [SKIOTIMPNOW20 (Information Management) ($H = 9.951$, $P = 0.019$, $df = 3$)]. This implies that, the importance of innovation management and information management as skills/ knowledge required for IOT implementation varies depending on the size of the organization that the respondents currently work in. In short, for small organization information management could be a least important skill/ knowledge while the same could be one of the most important skill/ knowledge for a large organisation. This is because aforementioned two p-values are higher than the significance level of 0.05, null hypothesis is rejected for these two variables only and conclude that medians of all SKIOTIMPNOW18 and SKIOTIMPNOW20 variables are not equal; hence null hypothesis (H0) for these two variables are rejected while alternative hypothesis (HA) is accepted with statistically significance difference in the way four organization sizes have responded. There were no statistically significant variables to the way people have respondents depending on their job role. Thus, the hierarchical level that each respondent is positioned in their organization do not necessarily influence for the way respondents believe to be the level of importance in skills and knowledge required for IOT.

Table 2. Kruskal Wallis Test for the importance of skills/knowledge for IOT (Internet of Things) implementation grouped for job role and organisation size

	Test Statistics for JOB ROLE						**Test Statistics for ORG SIZE**					
	NOW			**FUTURE**			**NOW**			**FUTURE**		
Variable	Kruskal-Wallis H	df	Asymp. Sig.	Kruskal-Wallis H	df	Asymp. Sig.	Kruskal-Wallis H	df	Asymp. Sig.	Kruskal-Wallis H	df	Asymp. Sig.
SKIOTIMP1	0.171	2	0.918	0.194	2	0.908	4.141	3	0.247	0.044	3	0.998
SKIOTIMP2	0.710	2	0.701	1.910	2	0.385	2.799	3	0.424	1.701	3	0.637
SKIOTIMP3	3.187	2	0.203	2.471	2	0.291	6.614	3	0.085	3.925	3	0.270
SKIOTIMP4	1.897	2	0.387	2.699	2	0.259	5.439	3	0.142	2.845	3	0.416
SKIOTIMP5	5.536	2	0.063	1.128	2	0.569	1.726	3	0.631	3.362	3	0.339
SKIOTIMP6	1.247	2	0.536	0.980	2	0.613	2.214	3	0.529	0.417	3	0.937
SKIOTIMP7	4.659	2	0.097	1.257	2	0.534	2.146	3	0.543	2.093	3	0.553
SKIOTIMP8	0.500	2	0.779	2.573	2	0.276	1.575	3	0.665	2.502	3	0.475
SKIOTIMP9	0.578	2	0.749	3.493	2	0.174	7.153	3	0.067	0.838	3	0.840
SKIOTIMP10	0.527	2	0.768	0.693	2	0.707	2.073	3	0.557	3.560	3	0.313
SKIOTIMP11	1.047	2	0.592	3.970	2	0.137	5.708	3	0.127	0.558	3	0.906
SKIOTIMP12	1.237	2	0.539	0.692	2	0.707	1.953	3	0.582	2.946	3	0.400
SKIOTIMP13	0.265	2	0.876	5.109	2	0.078	1.317	3	0.725	4.012	3	0.260
SKIOTIMP14	0.052	2	0.974	0.363	2	0.834	1.992	3	0.574	4.804	3	0.187
SKIOTIMP15	0.095	2	0.953	0.073	2	0.964	0.953	3	0.813	0.889	3	0.828
SKIOTIMP16	3.212	2	0.201	0.005	2	0.998	5.719	3	0.126	0.067	3	0.995
SKIOTIMP17	1.458	2	0.482	1.066	2	0.587	4.850	3	0.183	4.457	3	0.216
SKIOTIMP18	0.041	2	0.980	1.671	2	0.434	10.548	3	0.014	2.841	3	0.417

SKIOTIMP19	0.393	2	0.822	0.804	2	0.669	1.290	3	0.732	3.825	3	0.281
SKIOTIMP20	1.136	2	0.567	0.378	2	0.828	9.951	3	0.019	2.767	3	0.429

Descriptive statistics were then used to present the 'level of importance' of each skill/ knowledge dimension alongside the mean and standard deviation of the responses. Table 3 illustrates the extent to which respondents think the skills-knowledge dimensions are important for implementation of IOT and the extent to which they think they are important for future implementations. Interestingly, the three most important skills-knowledges for current IOT implementation are Leadership (SKIOTIMPNOW1), Team Work (SKIOTIMPNOW5) and Strategic Planning (SKIOTIMPNOW7). The situation is quite different when the study was viewed in the perspective of ‘future’. The three most important skills for IoT implementation in next five years are Innovation Management (SKIOTIMPFUT18), Strategic Planning (SKIOTIMPFUT7) and Information Management (SKIOTIMPFUT20).

Table 3: The skills/knowledge that may require in present and future job role, in managing implementation of IOT

NOW			FUTURE		
IMPLEMENTATION					
Variable	Mean	Rank	Variable	Mean	Rank
SKIOTIMPNOW1	3.58	1	SKIOTIMPFUT18	3.73	1
SKIOTIMPNOW5	3.54	2	SKIOTIMPFUT7	3.62	2
SKIOTIMPNOW7	3.52	3	SKIOTIMPFUT20	3.58	3
SKIOTIMPNOW6	3.44	4	SKIOTIMPFUT1	3.42	4
SKIOTIMPNOW18	3.42	5	SKIOTIMPFUT16	3.33	5
SKIOTIMPNOW20	3.31	6	SKIOTIMPFUT5	3.29	6
SKIOTIMPNOW2	3.25	7	SKIOTIMPFUT4	3.15	7
SKIOTIMPNOW16	3.23	8	SKIOTIMPFUT6	3.08	8
SKIOTIMPNOW4	3.17	9	SKIOTIMPFUT3	3.06	9
SKIOTIMPNOW11	3.13	10	SKIOTIMPFUT2	2.88	10
SKIOTIMPNOW3	3.12	11	SKIOTIMPFUT17	2.75	11
SKIOTIMPNOW17	3.00	12	SKIOTIMPFUT11	2.75	12
SKIOTIMPNOW12	2.96	13	SKIOTIMPFUT8	2.69	13
SKIOTIMPNOW19	2.92	14	SKIOTIMPFUT10	2.67	14
SKIOTIMPNOW10	2.90	15	SKIOTIMPFUT12	2.65	15
SKIOTIMPNOW9	2.83	16	SKIOTIMPFUT19	2.62	16
SKIOTIMPNOW8	2.81	17	SKIOTIMPFUT13	2.56	17
SKIOTIMPNOW13	2.77	18	SKIOTIMPFUT9	2.44	18
SKIOTIMPNOW14	2.73	19	SKIOTIMPFUT15	2.35	19
SKIOTIMPNOW15	2.62	20	SKIOTIMPFUT14	2.25	20

According to findings, ‘leadership’ is the most important skills and knowledge dimension that firms must consider when planning taking IoT on board. Requirement of a strong ‘Leadership’ within an organisation as well as an industry has been an area emphasised (Latham 1994) since the time Latham report was published. As purported by Pan (2018) , leadership often conflicts with ‘management’ as management and leadership are two very different concepts. Many studies draw a fine line between the two. Research has shown that the terms ‘leaders’ and ‘managers’ are often used interchangeably, although there are fundamental differences between the two. Managers are generally hypothesised as people who establish clear targets for their subordinates to follow. These targets or the processes towards achieving the targets may imitate the already established routes. Managers also make short term decisions to solve short term problems. Managers in general employ the so-called “hard” skills such as planning, directing, organising and keeping up with the target achievement. Leaders on the other hand generally employ more of the “softer” skills that would help them to guide their subordinates by influencing their thoughts and behaviours. These skills may include motivating employees; taking risks; persuading the employees to attain goals; compromising one thing, in order to achieve more valuable target(s); innovate and having strategic vision. In most cases, managers are appointed whereas leadership has to be earned. Therefore it is extremely crucial in building up the leadership skills as professional individuals are looking for new experiences, inspiration, training and clear guidance to improve their leadership ability (Toor and Ofori 2008). A research conducted by Kassim *et al.* (2009) on achieving IT business value also mentioned the importance of having a firm leadership. Eriksson *et al.* (2017) in their attempt to investigating the requirements for smart cities, big data and the built environment state that lack of persuasive leadership is holding back the potential of making the best possible use of Internet of things.

Second, with reference to firms’ point of view, it is vital setting up a collaborative working environment between the employees within an organisation. Hence firms need to develop specific team-work collaboration management capabilities stem from organisational routines, management of manifold interdependencies between projects and/ or departments within the organisation itself. This would also entail promoting inter-departmental and/ or inter-project learning and then align the lessons learned with project (or context) specific adjustments. These team-work capabilities have to be based on: relational and trust building capabilities; learning from each other capability; and building upon everyone’s creative thinking (Reinhard *et al.* 2016).

Third, IoT market is expected to reach massive turnovers, but gaining a competitive advantage from IoT for organisation will require a strategic plan backed by appropriate skills set. A research paper published by Betts *et al.* (1991) on exploring the strategies for the construction sector in the information technology era mentioned that the use of information technology in construction is going to be extending beyond the orthodox information technology applications such as for efficiency improvements or discrete operations. Instead, collaborative organisations such as commercial enterprises, government agencies and professional institutions are making progressive propositions in using information technology strategically to boost ‘value’ and ‘competitive edge’. Being specific for the use of IoT, the accelerated growth of IoT market is (and will be) fuelled by the increasing use of cloud platforms and interconnected networks and devices in businesses (Dave *et al.* 2018). Therefore, the need for a well- documented strategic planning required being addressed by the ability to monetise this cloud platforms and connected devices to match the accelerating flow of data generated by interconnected devices. Further, an effective planning of IoT strategy should create competitors in the data-driven competitive market (Dave *et al.* 2018).

Organisations looking for a far-ranging vision towards future may create a strategy that uplifts skills around ‘innovation management’ and ‘information management’. IoT makes the running of a building a data-driven process that creates a substantial noise by transmitting large volumes and varieties of information at almost light speed (CEBR 2016). Managing this IoT data implies developing and executing relevant data architectures, standards, policies, practices, and procedures that meet the lifecycle of this data expanded to fully utilisation. Management segments for ‘information’ may also include scalability, agility, security, privacy, data governance and many more. Innovation management on the other hand makes an indispensable area of concern especially considering the common problems in the industry. Construction worksites have been slow to adopt IoT (Dave *et al.* 2018). One reason for this could be the fragmented nature of the industry with contractors and smaller subcontractors splitting up the workload globally (Woodhead *et al.* 2018). There are issues around standardising IoT implementation as well. Hence, Innovation management is a much needed skill that every organisation that expects a sustained outcome out of IoT implementation must build.

5. Conclusion

As emerged from this research, firms need to rethink about their organisation strategies along the lines of skills and knowledge needs, in order to fully implement as well as to exploit the opportunities offered by IoT. Doing so the firms develops their capacity to implement IoT and thereby create their own competitive advantages (WEF, 2016). Knowing the right skill and knowledge demand would help firms in bridging the skill gap between traditional construction processes and digitalised processes. The aim of this research was to investigate the skills and knowledge requirement to implement IoT in construction. Two research questions were set for the inquiry. In response to the first research question (RQ1): What are the most important skills/ knowledge dimensions CURRENTLY required to implement IoT in construction?, the study was able to identify the three most important skills as leadership, teamwork and strategic planning. In response to the second research question (RQ2): What are the most important skills/ knowledge dimensions required to implement future IoT in construction, within the next five years?, the findings revealed that the three most important skills for future IoT implementation would be Innovation Management, Strategic Planning and Information Management. The study implies that 'strategic planning' is a skill and a knowledge dimension that is vital not only for the present times but also for the future. The findings are encouraging firms' growth and competitive edge through the IoT combined with the identification of important skills- knowledge sets. Furthermore, it also emerged that 'innovation management' is an important skill-knowledge dimension and even more important than the extent to which 'leadership' shows its significance for current scenario. Hence, firms must pay more attention in the management of innovation processes, together with change management because change management goes hand-in-hand with innovation management (Economist Intelligence Unit, 2015). When developing the strategic intent, firms must also establish a clear vision of how they are going to position the technology strategy in their overall business. Moreover, firms need to plan in advance the diverse activities such as: collaboration within teams, leadership structure in relation to the goals of the organisation. It is also important to appreciate that the development of these skill-related strategies must be tailor-made for different sizes of organisations as the results of the investigation presented in this paper highlights a certain level of influence from organisation size for the importance of certain skills/knowledges.

This paper provides important contributions to both academic, public and private bodies such as government, construction organisations and research bodies. This study highlights that organisations in construction have to internally encourage the IoT implementation by creating skills and knowledge platforms especially around leadership, collaborative working practices and strategic planning. In reference to firms' point of view, it is vital to set up a close collaboration between the employees within an organisation before concentrating on the stakeholder collaboration within the supply chain. Organisations looking for a broader horizon may lay out plans towards building skills around innovation management and information management. The findings presented in this paper represents a part of a larger research project that looks at implementing digital technologies in construction; hence further research could be conducted in a similar vein but for more extended research avenues such as to explore the need for training and acquiring skills and knowledge in construction IoT. The research presented in this paper is repetitive in nature for other technological innovations (other than IoT) fuelled by 4IR.

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