Chapter 17
Transforming the Productivity of People in the Built Environment:
Emergence of a Digital Competency Management Ecosystem

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ABSTRACT

This chapter explores how we create and support a digitally enabled, agile, competent, and ultimately, productive workforce and determines the key research questions that need to be addressed if Digital Built Britain (DBB) is to provide return on investment and succeed as the catalyst for evolving the manner in which we conceive, plan, design, construct, operate, and interact with the built environment. The proposed vision is a digital competency management ecosystem where interdependent stakeholders are incentivised to work together in coopetition to create, capture, infer, interpret, specify, integrate, accredit, apply, use, monitor, and evolve competence as a working (data) asset. This needs to be in a consistent, objective, explicit, and scalable manner, with end2end transparency and traceability for all stakeholders that overcome the challenges of competency management. Moreover, a core element must be an ecosystem organised around digital infrastructure of competency frameworks and other knowledge sources of competence, so that competency frameworks are in digital operation and dynamic context.

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INTRODUCTION

A successful evolution within any industry or sector is often seen as a combination of People, Process, and Technology (Arayici, 2011). However, it is difficult to quantify the relevant proportion of investment into People, Process, and Technology suggested by the Construction Sector and Government strategies and reports. The Digital Groundwork report (PlanGrid, Inc., 2019) stated that 50% of industry professionals say that improving digital skills[1] will be a key focus for their business over the next three years. However, in the latest NBS Annual BIM Report (NBS, 2020), 63% attribute the barrier to BIM use to a lack of in-house skills/expertise, and 61% to the lack of training; both continuing to remain two of the top three reported key barriers to the successful adoption of BIM and digital transformation over the last decade. The Construction Manager Annual BIM survey 2020, similarly, reports that poor digital skills are holding back the adoption of BIM with 64% attributing the main organisational barrier to the adoption of BIM, or further adoption, to the lack of digital skills (Construction Manager, 2020). Furthermore, when considering the main barrier to productivity in their business, industry professionals most commonly point to a lack of skills amongst employees (40%) and talent shortages (39%) (PlanGrid, Inc., 2019).

When we consider the construction sector is comprised of a significant proportion of micro and small and medium sized enterprises (SME's) that are essential to the whole built asset life cycle (over 99% (BIS, 2013; Designing Buildings Wiki, 2019)), the development of their digital skills is critical to facilitate the ongoing digital transformation (CLC, 2019). Improving digital skills and the ability to use digital tools of SMEs could add £9.9 billion, i.e. 0.5% of total UK GDP (Oxford Economics, 2020). However, according to the 'Bricks, Mortar and Digital Transformation' report, SMEs within the UK construction sector risk being left behind if they do not embrace the digital transformation journey (Zen Internet, 2019).

The implementation of BIM not only demands the use of computer-aided design, modelling, and collaborative tools, but also requires a shift in/or having a flexible mindset (sometimes referred to as metaskills) to embrace these techniques in all construction processes. Therefore, BIM training can either mean 'learning to use technology' or 'process focused' with the majority based strongly on the PAS/ISO standards (SFT, 2018). Thus, Barley (2019) asks, do we do more than, "*give people the process and the technology and call those who reject it luddites or laggards*"?

The digital transformation picture is complex and fragmented; however, there is little evidence of industry-wide initiatives that support the 'People-centric' focus required to successfully deliver 'transformational change' on a scale that is unprecedented. The COVID-19 pandemic offers an unprecedented opportunity for not only new digital ways of working but also the digitalisation related to work, people, and competences. There is an urgent need for digital talent in the built environment sector to drive BIM and digital transformation not only in the UK but across the world.

The Digital Built Britain (DBB) vision is far more-wide ranging than that envisaged for the 2016 UK Government BIM mandate. It follows that, although BIM training and certification is an important first step towards the digital transformation journey within the built environment, success will require an evolved upskilling[2]/reskilling philosophy to develop a digitally competent and agile workforce capable of supporting the emerging digitally-enabled processes, purpose driven information flow, and the collaborative behaviours that underpin them. The post pandemic crisis further supports the need for such an approach to facilitate the sector's future recovery in the emergence of a 'new normal'. The Client Leadership Council (CLC) launched a Recovery Plan in June 2020 to drive the recovery of the construction and built environment sectors following the COVID-19 pandemic and the resulting economic downturn

(CLC, 2020), through a three phase strategy to restart, reset, and reinvent the sector. The modernising of upskilling, training, qualifications, accreditation, and certification systems for construction to ensure that this is fit for purpose; supporting the delivery of a competent workforce required by the future industry, and the multi-skilling of the construction workforce to increase flexibility and adaptability, are stipulated as part of the reinvent/transform phase. The training, certification, and qualification systems need to be driven by dynamic data so competency demand is explicit. The problem has been the unsuccessful focus on supply-side interventions when policy needs to be focused on demand-led interventions. The use of qualifications or 'cards' as a proxy for supply, from a competency management perspective, is neither granular, multi-dimensional, nor dynamic enough.

It is vital to ensure that individuals, teams, and organisations have the right knowledge, skills, abilities, experience, behaviours, and attitude at work, i.e. 'competencies', to carry out tasks/activities they are appointed to perform. It is also vital for Clients, when appointing individuals, teams and organisations, to undertake construction operations, to ensure they are 'competent' to be able to conduct the work appropriately (ICM, 2020). The Dame Judith Hackitt (DJH) (Hackitt, 2018) report entitled, "*Building a Safer Future*" that followed the Grenfell Fire tragedy, concluded that the current system of building regulations and fire safety is not fit for purpose and that competence development and culture change are required to support the delivery of buildings that are safe now and in the future. These systemic failures occur in the delivery of all projects within the construction sector and the wider built environment. Therefore, a competence problem exists resulting from the lack of effective strategies for competence definition, development, management and, importantly, assurance. The sector, unlike Rail, has not invested in competency management systems. Although, there are positive indications, such as in Social Housing Maintenance Sector, that is developing a UKAS TPS 69 Standard for a Competency Management System (NHA, 2016).

The subsequent DJH 'Raising the Bar' interim report (CIC, 2019) and the recommended 'overarching system for overseeing competence' validates the need for a systemic approach and many (but not all) of the stakeholders. However, it does not address the extent of the 144 competency supply-demand interrelationships and activities (Figure 2), or how the system will be fully implemented or digitally-enabled, including a new 'framework of standards', such that competence truly acts as the currency of the labour marketplace. In countries such as Canada, where the industry is highly regulated, competency acts as a basis for transaction and comparison.

Furthermore, the DCOM 'A Call to Digitise' report (DCOM, 2019), states that, so far, there has been no meaningful suggestion of either the digitisation of the regulations or compliance systems despite the concerns raised by the Hackitt Review around responsibility and departure from regulations being a systemic problem. However, this call to action does not explicitly recognise the need to digitise knowledge sources of competences (e.g. competence frameworks) and the competency assurance system, despite a core recommendation of a new 'framework of standards'.

The final report 'Setting the Bar' (CIC, 2020), which should be read in association with the draft Building Safety Bill (2020), sets out a new system that includes a comprehensive set of competence standards underpinned by rigorous third party assessment for individuals and companies and third party accreditation of those who carry out the assessment. The report neither acknowledges, nor promotes a digital vision for a functioning competency system, or where a framework of competency frameworks sits within this. This despite Hackitt's call to action for the urgent need for radical changes in culture, competencies, and processes, and that digital will be the norm (NBS Summit, 2020).

The Cambridge Centre for Smart Infrastructure & Construction 'Flourishing Systems' report (CCSIC, 2020) propose a people-focused 'infrastructure industry' that recognises infrastructure as a complex, interconnected system of systems, and which considers value in terms of outcomes and human flourishing. In addition, it states that "*the long-term viability of infrastructure requires it to be sustainable, which includes the people who sustain the system of systems themselves being supported in their wellbeing and safety, their employment security, and in the development of their capability*". However, an ecosystem approach to competency (and its management) is not explicitly considered as a key system within the system of systems or the need for digital infrastructure to support this. The CDBB recognise that a people-centric approach to competency evolution and supporting the upskilling/reskilling to ensure a competent and digital workforce requires digitalisation.

Similarly, a digital ecosystem approach to competency and its management and assurance (to ensure there is a competent supply and 'good work' now and in the future (RSA, 2019)) is not considered within the CLC Roadmap to Recovery plan to 'reinvent' the construction and built environment sectors, and drive a more capable, professional, productive, and profitable sector post-COVID-19. In addition, 'skills' rather than 'competence' is the choice of language despite the increased forensic lens of competence assurance post Hackitt. While there is continued investment targeted at more general digital literacy and skills frameworks, through the DfE, CITB, CDBB, etc., such initiatives still take a classical information model (pdf, static, narrative format, schematic in hierarchy, and time bound) approach to competency frameworks when a systems model is required.

The lack of clear and consistent information management strategies and the operationalisation of competency management mean that finding the right information to make timely decisions by the right person is often impossible. Information management is part of digital competence requirements (CDBB, 2021). In the 'Building a Safer Future' report, the term the 'Golden Thread' of information is used. Of these two, the 'Golden Thread' is likely to be achieved through 'Technology' and 'Process'. Consequently, this may be easier to achieve than the 'Competence' issues, which, enabled through technology, will present a much greater challenge. The Steering Group on Competences for Building a Safer Future that was set up by the Construction Industry Council in response to the DJH report (Hackitt, 2018), intends to ensure a joined-up approach to achieve a comprehensive, coherent, and robust framework for the competence of all those creating, maintaining, and managing higher risk residential buildings.

There is little argument that successful projects are characterised by the right people making the right decisions at the right time with the right information. In the context of "Building a Safer Future", the 'Golden Thread' means having appropriate information at hand to make informed decisions within the expected timeframes. However, 'competence' ensures there are the right people available to specify the information required to make those decisions, and correctly interpret the received information. Furthermore, it can be argued that productive work only occurs when competent people specify the work that must be done, which is in turn, carried out by other competent people. The productivity of people comes from effective mediation between competency supply and demand, and enabled by the flow of appropriate and correct information. The productivity problems of the construction sector and wider built environment is therefore likely to be due to as much a manifestation of the failures relating to the mediation of competency supply and demand, as the failures relating to the flow of purpose driven information.

This chapter presents the findings, and further research work, from the Pedagogy and Upskilling Network (PUN, 2019) report. PUN is a network of over 50 collaborators drawn from research, practice, and other relevant areas, commissioned by the Centre for Digital Built Britain (CDBB) to explore how we create and support a digitally enabled, agile, competent and ultimately, productive workforce. Results

from a series of network workshops proffers key research questions that need to be addressed if DBB is to both provide return on investment, and succeed as the catalyst for evolving the manner in which we conceive, plan, design, construct, operate, and interact with the built environment (CDBB PUN, 2018). Over the course of the network, two primary questions emerged:

- *What is required to facilitate the emergence of a digital ecosystem for the effective mediation of competency supply and demand within the construction sector and wider built environment that supports digitalisation and productivity?*
- *How does the sector support the competence development, management and assurance of individuals, teams, and organisations throughout their career in the built environment?*

While competency frameworks are obviously an important knowledge element of a digital competency management ecosystem, they were not the prime focus of the research. Furthermore, no conceptual distinction of potential or actual is made between competence(s) and competency(ies). The latter is considered as a collective noun of the former.

These are broad topics and the findings suggests a number of questions and recommendations relevant to PUN that need further attention at the next stage of the CDBB initiative. In addition, a successful response will require different combinations of leadership from industry and government, fundamental research, and pilot projects to rigorously measure impact and effectiveness. The proposed vision is to imagine a ***digital ecosystem of competency management where interdependent stakeholders are incentivised to work together in coopetition to create, capture, infer, interpret, specify, integrate, accredit, apply, use, monitor, and evolve competence as a working asset just like any other data asset***. Furthermore, this needs to be in a consistent, objective, explicit, and scalable manner; with end2end transparency and traceability for all stakeholders that face the challenges of competency management. With an increasing overlap of competences across sectors, professions, trades, roles, and disciplines, a core element must be an ecosystem of competency frameworks, and competency frameworks in digital operation and dynamic context; as opposed to the current traditional informational model of competence. In addition, a digital competency management ecosystem relies on robust lifelong learning opportunities that empower individuals to take responsibility for managing their own career, i.e. ***Conscious Competence Evolution***, as well as, allowing employers to both recognise and reward innovation.

ECOSYSTEM STAKEHOLDERS

The key challenge of DBB is to ensure that the UK is able to harness new technologies and digital connectivity to transform the built environment and to deliver real social and economic benefits to its citizens. Therefore, it is necessary to assess the impact of, and implications for, the various (Digital Built Environment) stakeholders that comprise the ecosystem, including (but not exhaustive):

- Clients, and by extension, those involved in procuring projects;
- Those representing entities (either a company or individual) and engaged to deliver projects (who in turn, must be able to demonstrate their organisations have the collective competence, capability, and capacity to discharge their contractual obligations);

- The myriad of professions who are involved in delivering projects at any stage of the asset life-cycle, including the commissioning, designing, constructing, maintaining, operating, altering, and decommissioning of Built Environment assets;
- Those responsible for educating and upskilling current (and future) professionals;
- Those responsible with certifying and assuring the competence of practitioners;
- Those responsible for the regulatory framework and the development of standards such as the Engineering Council that is aiming to get more protected professional status without operating in a transparent and digitised manner; and
- The citizens who interact and use the built environment for all aspects of their day-to-day lives, not just for business.

In order to be successful, we should ensure that we reach out beyond traditional built environment professionals and include experts from other domains and industries who can complement the ecosystem with new propositions, e.g. manufacturing, finance, IT, agile business practice and competence management. On full consideration of the wide range of stakeholders and their interactions within the ecosystem, the classification of initiatives by People, Process and Technology is particularly nebulous when considering 'People'. This classification specifically misses the critical distinction between the 'individual as a stakeholder' and the 'organisation (that comprises People) as a stakeholder'. Interventions can be aimed at either the individual, the organisation, or through intermediaries for work and workers (e.g. many individuals are not employees, but are other types of workers). Furthermore, there are increasingly different types of work and workers, which makes mediation more complex (RSA, 2019). To make this relationship more explicit, the classification of initiatives in Figure 1 was proposed.

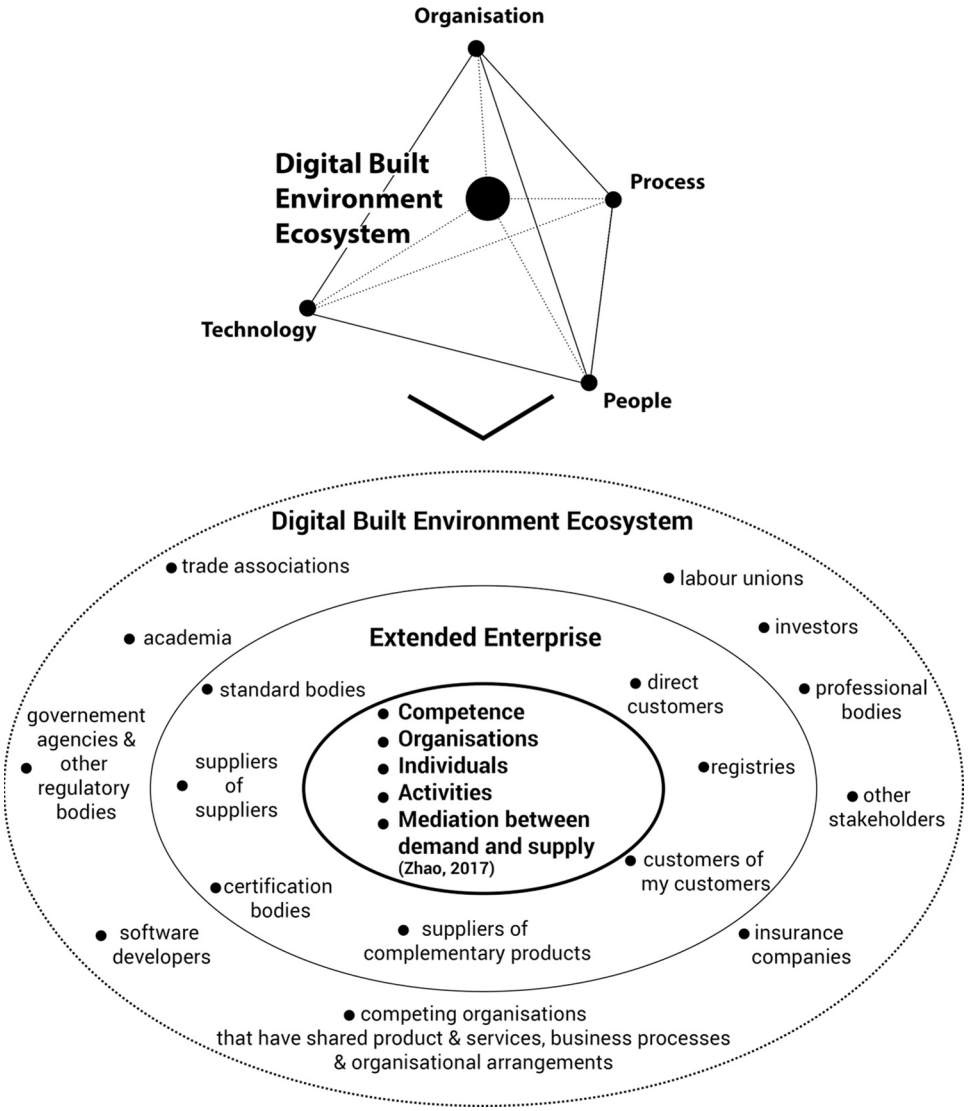
Furthermore, the proposed initiatives are classified as having 'Research' focus (TRL 1→5) teams or an 'Implementation' focus (TRL 6→9). While the next stage of CDBB will have a research focus, the implementation-focused initiatives also need attention, as success relies on the interdependence of all initiatives across the ecosystem. Furthermore, research focused initiatives should consult with industry to assess whether any complementary implementation focused initiatives are required to ensure that long-term impact is possible. This includes partnering with industry domains that are the thought leaders in digital Human Resource Management.

DIGITAL COMPETENCY MANAGEMENT ECOSYSTEM

The ecosystem has a critical function as it sets out the norms of interactions between individuals and organisations, and organisations with other organisations (many-to-many relationship of competency demand and supply); process and technology are the means by which these interactions take place. A recent study assessed the digital transformation journey of the Architecture, Engineering, Construction and Operation (AECO) sector in Finland and concluded that an overemphasis on technological capabilities in practice and the extensive portfolio of national R&D initiatives, which mainly target productivity and efficiencies with technological developments, did not lead to the systemic change in the established ecosystem, nor led to the emergence of the new Digital Business Ecosystems (Aksenova *et al*., 2018). As a lesson learnt, the government of Finland established a new programme in 2016-2018, named Kira-Digi. Kira-Digi has brought about a new experimental neutral platform to coordinate the discussions between the government departments, city stakeholders, AECO industry stakeholders, and

complementary industries to support the emergence of the digital business ecosystems, while "The €16M programme's vision is to develop an open, interoperable information management ecosystem for the built environment" (Heiskanen, 2017).

Figure 1. Proposed alternative to People: Process: Technology (Figure on ecosystem is adapted from Moore (1997) and the concepts on an ecosystem of competency mediation between demand and supply are adapted from Zhao (2017))



Clarysse *et al*. (2014) analysed a knowledge ecosystem around the region of Flanders that aimed to stimulate knowledge creation in technology hotspots on the assumption that these knowledge networks will lead to the region's competitiveness. Despite the financial support network, and a 100% publicly-funded and well-structured knowledge ecosystem, the emergence of new businesses has been almost

non-existent. This posed serious implications for policy makers in the need to learn that investment in the creation of knowledge ecosystems does not necessarily lead to the development of business ecosystems, because the value creation processes for knowledge and businesses are fundamentally different, while local actors might struggle to attract global players to support the emergence of new business ecosystems. Different types of ecosystem require specifically tailored policies and power recognition. Furthermore, Rinkinen and Harmaakorpi (2017) have recognised that policy development for ecosystem evolution is an important field for future empirical studies; hence, the policy positioning on ecosystem creation is in its infancy. There have been successful skills projects to stimulate ecosystem growth in the automotive sector in Limburg Province that address the cyclical nature of work and keep the skills in the province.

In the context of the growing organisational complexity of the Digital Built Environment, which is driven by an adaptation to high uncertainty, and the central role of collaboration, the ecosystem approach is becoming more important. A multidisciplinary approach to competency management across sectors, disciplines, professions, etc., matters more than targeting productivity improvement through rapidly changing technologies. There is a significant risk that, if the Digital Built Environment does not re-design its policies, institutional and industrial landscape in an ecosystem-based manner that acknowledges the increasing granularity, complexity, and turbulence of the environment, as well as placing the individual at the centre of the competency management, current initiatives will have limited impact in terms of innovation (Autio & Thomas, 2014; Clarysse *et al*., 2014; Aksenova *et al*., 2018, Russell and Smorodinskaya, 2018).

Therefore, the relationships between the professional institutions, universities, government, the industry, and other accreditation and certification stakeholders of the digital competency management ecosystem are critical if a competent workforce is to mitigate risks. For example, funders and insurers could be critical partners to ensure that real change happens within the Digital Built Environment, particularly away from projects covered by the 2016 UK Government BIM mandate. In addition, many of the traditional paradigms and structures are not fit-for-purpose and should be re-examined within the context of the emerging digital interconnected world. There is a considerable risk that, if we attempt to embark on a digital transformation journey with the handbrake on, we will not get far!

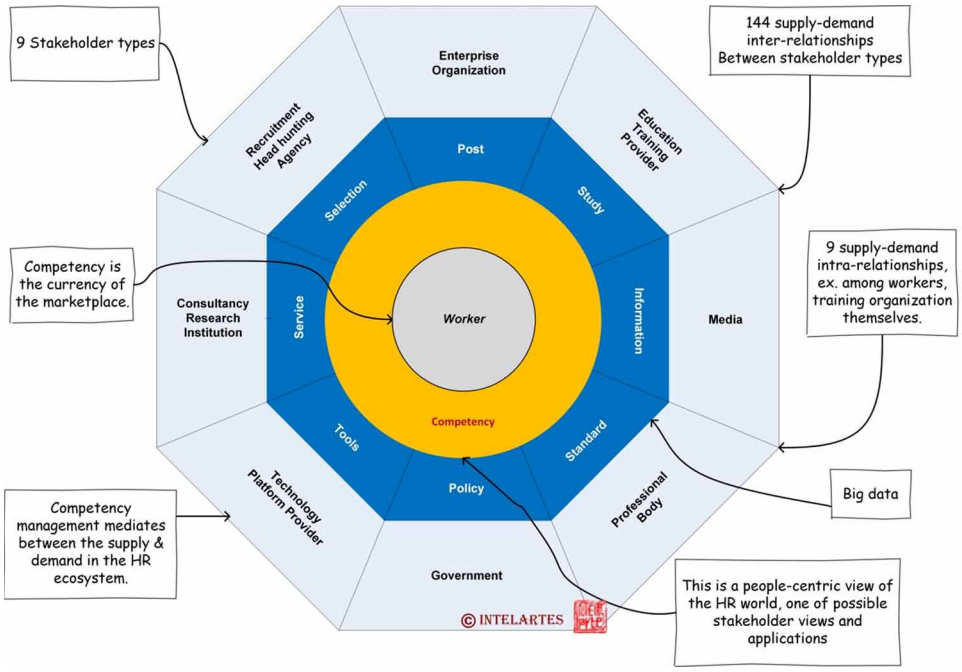
COMPETENCY SUPPLY AND DEMAND

The mediation of competency supply and demand directly impacts productivity (Zhao, 2017) as much as the flow of timely and appropriate information, i.e. an Information Transaction. Information is used in the broadest sense of data, which is formatted to allow the inference of meaning. However, does the mediation of competency supply and demand mirror the information transactions that occur between parties or individuals?

OECD (2017b) identified within the UK, a high level of mismatch between the skill supply and skill demand, and that this is due to poor mediation in conjunction with ineffective supply focused interventions facilitated by the UK government (IPPR, 2017). Therefore, a transformation in mediation between demand and supply is a critical issue for competency management. The two key stakeholders in competency mediation are those who demand competency (i.e. asset owners and employers) and those who supply competencies (workers); they are the primary stakeholders. The secondary stakeholders (government, professional bodies, trade associations, etc.) are mediators between the supply demand relationships. Research on an ecosystem approach to mediation of competency demand and supply has established

that there are 144 competency supply-demand inter-relationships between 9 stakeholders types (Figure 2) (Zhao, 2017a, b; 2018). This involves many-to-many relationships, activities, and transactions depending on who is demanding competency (employers and importantly, owners), who is supplying the competencies (workers), those who are overseeing competence (regulators, etc.) and those facilitating competency by providing training, assessment, validation, verification, accreditation, certification, or other services (Zhao, 2017a, b; 2018). A critical component of this ecosystem is that workers are a key stakeholder, i.e. it is people-centric.

Figure 2. Ecosystem of Competency Demand & Supply (Zhao, 2018)



There is a need to build competency profiles of individuals to understand competency supply, and to conduct a more intelligent analysis of work and the value of work to understand demand and produce target competency profiles. There is an increased UK Government focus on meaningful (good) work following the Taylor Review (2017). The innovation and challenge is how to make the value and meaning of work and competency explicit to enable this. Currently, the proxy for competency demand is occupation and role. The proxy for competency supply is qualifications or 'cards'. The better articulated demand side of competency could potentially explain the systemic cause behind the low productivity of the UK workforce. Ultimately, this is a cascading relationship throughout the entire project/asset supply chain where the primary stakeholders are the clients and asset owners. Competence is not just about knowledge and skills, but is the application of a combination of such dimensions as knowledge, skills, abilities, experience, behaviours, attitude, etc. at work (Zhao, 2015a, b). In addition, competence is only truly gained through its repeated application and verification at work. Moreover, Susskind & Susskind (2015), in their definition of competence/practical expertise, also recognise machines and systems – *"practical expertise which should not only include formal knowledge, know-how, expertise,*

experience, and skills of traditional professionals, but also the relevant output of various machines and systems". This is critical as it underlies why the solution to the productivity problems of the industry does not lie in 'training' alone, in that:

- Education and training can never plug the competence gap as they only ever provide the fundamental knowledge, foundations skills, or theoretical behaviours that individuals should exhibit in their work. Education cannot substitute the experience that comes from having applied any of this in 'the real world';
- Current Continual Professional Development (CPD), including re-validation (BSI, 2020), is not fit-for-purpose (ICE Skills Review, 2018). While most Professional Bodies' codes of conduct for CPD focus on remaining competent to undertake work activities, current CPD processes do not actually provide any assurance of this;
- Current certification schemes, in the UK and across the world appear to be limited towards BIM and skills, focusing on particular technologies, rather than adopting broader schemes for digital competence that include consideration of the ISO/IEC 17024 scheme development for the certification of competent persons;
- Qualifications gained through education and training (including CPD) are a poor proxy for competence as they only provide, at best, the confidence that an individual has a foundation knowledge or skills, and not the experience of having applied it in 'the real world';
- The likelihood of increased certification of products, process, systems, organisations, or persons and increased regulation (such as a Product Regulator in the UK) will impact the contextualising factors that will affect competency requirements; and
- Knowledge and data about competences is for both humans and machines.

Moreover, could emerging Immersive Technologies challenge the pre-eminence of the 'real world' as the only place to get experience? The professions associated with construction and the wider built environment has evolved to their current state over many years. Traditional project delivery methods have failed the construction industry and its clients due to their lack of confidence in shared data and their incorrect assessment of how to minimise risk and liability. These systemic problems are manifestations of one or more of the following:

- A failure to engage early with the parties who have appropriate competence to both supply and interpret information on which decisions are to be based. This particularly involves the failure to engage construction and operation specialists early enough in design;
- **Inconsistent definition of activities** leading to inconsistent information requirements and programming;
- Inconsistent exchanges of information at the project inception, e.g. requirement capture, briefing, proposals, and pricing;
- Inconsistent, incomplete, ambiguous, and ultimately unverifiable information deliverables leading to subjective decisions across the project stakeholders and lifecycle;
- Lack of standards or codes relevant to offsite construction methods;
- Inconsistent and non-transparent cost data leading to inconsistent pricing;

- Deadlines associated with information deliverables are allowed, and almost expected, to slip inconsistently in the notification of the project, both in terms of the information and the timeliness of the notification.
- Inconsistent communication across the project; both digitally in terms of the interoperability and overreliance on written/verbal instructions and feedback, which cannot be audited.
- **The lack of any consistent framework or digital infrastructure to facilitate the mediation of competency supply and demand**.
- The lack of both a system/infrastructure for the capture and utilisation of 'lessons learned' from project to project and the lack of a 'lessons learned/shared' culture within the industry.

Any one or combination of the above can undermine the efficiency and efficacy of the asset during the delivery, in-use, and end-of-use phases (Bernstein, 2018). If existing traditional (document-centric) processes are just simply digitised, does this risk constraining the potential to find solutions to the underlying issues facing the construction sector and wider built environment? This is reflected in the distinction between Digitisation (digitising current processes, systems, and products) and Digitalisation (creating new processes, systems, and products unfettered by the constraints inherited from the document-centric world). Those highlighted were within the remit of PUN, while it was recommended that the other points are acknowledged and covered by other CDBB or wider industry initiatives.

Inertia in the Paradigms of the Construction Sector and the Wider Built Environment

There is considerable history and inertia regarding the professions and trades of the built environment, and in particular, the entrenchment of 'roles' and 'occupations'. This has led to the development of established professions, and particularly, professional and trade institutions, with detractors in their conduct, and practice tending towards protectionism, alongside resistance to change, the reinforcement of silos, and the preservation of hierarchies (Morrell, 2015). Furthermore, the Hackitt report (2018) stressed the requirement for each body (professional, trade, or skills body) to define the competences that are unique to the activities over which they have primacy, thereby confirming that activities are central. 'Occupations' and 'professions' have, in turn, become a proxy for competence demand (Cedefop, 2013), e.g. in the majority of large built environment projects, workforce planning is based on 'we need 'n' roles (e.g. project managers)'. In reality, the boundaries between professions are becoming blurred with the emergence of digital innovation. Theoretically, any organisation can participate in a design or construction project in any location (Langford & Male, 2008) and digitalisation blurs the professional roles and responsibilities for information creation. If we are willing to accept that the current information flow processes are neither dynamic nor granular enough to capitalise on the potential of the emerging digitally connected world, and we can show that information transactions mirror the mediation between competency supply and demand, then it follows that the proxies we use for competency supply and demand are also neither granular nor dynamic enough for the changing world of work. The OECD (2017b) identified in the UK:

- High level of mismatch between skill-supply with skill-demand due to poor mediation in conjunction with ineffective supply focused interventions facilitated by the UK government;
- Low demand for higher order competences;

- Increasing polarisation between high-end skills and low-end skills, which increases mobility challenges.

Ultimately, competence assurance, as recommended by Hackitt (2018), requires the capability (including technologies and processes) to intelligently manage competences, people, and work. *However, do employers actually know enough about the competency of their workers at any point in time?*

Over the past twenty-five years, the UK skills policy has primarily focused on boosting the supply of skilled or qualified labour. Despite significant progress on this front, as policy in this area is relatively underdeveloped in the UK, its productivity continues to lag behind those other OECD countries (Brinkley 2017; Payne, 2008). UK employers spend less on training than other major EU economies and less than the EU average. Participation in job-related adult learning has fallen significantly in recent years to the lowest ranks (Brinkley & Crowley, 2017). However, the UK has record-high employment levels and very low jobless rates compared to most OECD countries (OECD, 2017b). The UK sector's focus on the 'shortage of skills' implies both the recognition that there is a problem and an appetite for policy to tackle the challenge. However, despite initiatives in this area, there has been little progress on productivity in the last 30 years (Schouten, 2016; IPPR, 2017; ICE Skills Review Group, 2018). It seems reasonable to conclude that initiatives focused on training alone will not solve productivity challenges. Therefore, future initiatives should consider how to address BOTH competency supply and, in particular, competency demand, and how to improve mediation to reduce mismatch. The continuous emphasis in the UK on 'skills gaps or shortages' belies a more complex and multi-dimensional challenge around competency mismatch (OECD 2017a). As skills are only one dimension of competence, then a best-fit decision to employ an individual based on a skills profile alone may be different to a decision taken on an entire competence profile. Thus, *does a 'skill-centric' view of a person's suitability for employment have implications for diversity and social mobility? Skills also have an increasing short shelf-life and automation will only accelerate this.*

Furthermore, digital change shifts the composition of demand and supply with concern raised over the increasing gap between digital and non-digital, and between high and low skilled workers. By 2022, no less than 54% of all employees will require significant reskilling and upskilling (World Economic Forum, 2018a). As workforce transformations accelerate, the window of opportunity for the proactive management of this change is closing fast. If the transition towards digitalisation is managed poorly, it poses the risk of a widening competency gap, greater inequality, and broader polarisation (World Economic Forum, 2018a). Furthermore, the industry lacks the dynamic capabilities to build the necessary competencies for a digital transformation (World Economic Forum, 2018b), while missing the human dimension and the need for individuals to flourish in the system. Therefore, a greater shift from the inward-looking goals of individual organisations to an ecosystem with a coopetition approach is required. The traditional structures of 'roles' and 'occupations' could therefore act to constrain the skill/competence composition of the employer, its contribution to job growth, and ultimately to productivity.

To address these challenges, two further key questions need to be addressed: 1. *what does upskilling look like through the lens of dynamic competency management?* and 2. *what is the digital infrastructure required to support the mediation of competency supply and demand?*

The link Between Competence and Activity at Work

All individuals have competency, which can be expressed in terms of an individual's knowledge, skills, experience and behaviours related to the work activities they have done, can do, are qualified to do, are certified to do, want or willing to do. This profile, in part, signifies an individual's effectiveness in the day-to-day activities required as part of their role, job, or task. This is not how effective they are at their role, job, or task, as other evidence sources are required to provide assurance of effective performance. Other sectors, such as Oil & Gas, are more mature in the implementation of organisational competency management to drive productivity and ensure compliance.

A role can be an aggregation of all the activities an individual carries out, but often two individuals with the same role may carry out different activities. Likewise, different roles in different organisations require individuals to carry out different activities or associated duties. Profiles are the pivot of business logic for the nine key stakeholders of a competency management ecosystem. There is currently no construct of competency profiling to implement a framework or frameworks post Hackitt.

Activities are the fundamental building blocks of work, whereby, for the purpose of this chapter, an 'activity' has a definable and intentional result. When we look at built environment projects, which involve multiple organisations collaborating and contracting with each other, fundamentally, projects are also a collection of activities. ***The activity, the information required to carry out that activity, and the competency of the person to carry out that activity, are all intrinsically linked***. The potential that consistent structured information could have for productivity is well recognised. For example, the Industry Foundation Classes (IFC) is a non-proprietary schema/standard for defining how information can be structured to describe the built environment. However, the built environment has no such schema/standard to define how activities can be consistently and semantically linked. Of the 'BIM' frameworks that currently exists (SFT, 2018), many are now out of date and have not been maintained, some are for specific user groups and are not suitable for wider application, are internationally based and have not been tested in the UK context, or have been adopted by specific users, but do not have a broader uptake.

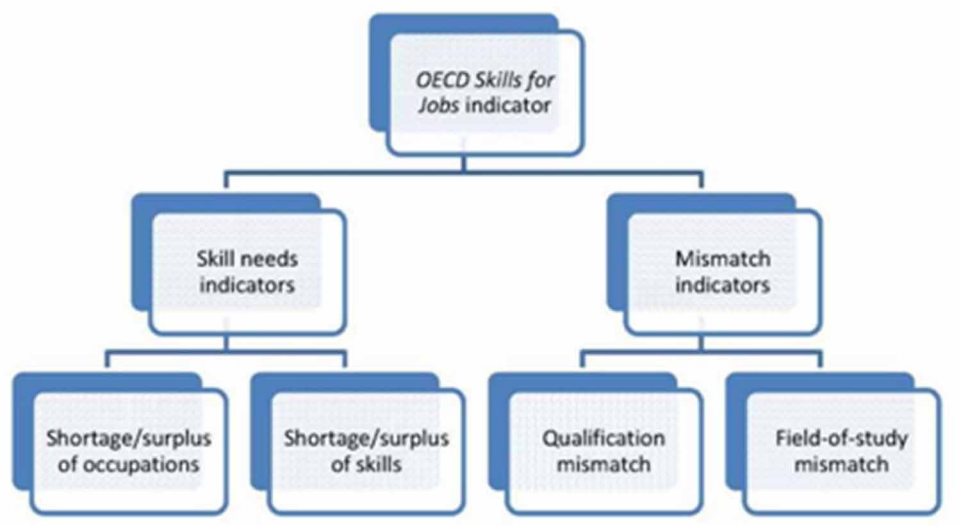
Furthermore, although the report by Bush and Robinson (2018) for the Scottish Futures Trust investigated the challenges of "Developing a BIM Competency Framework" based on traditional occupational roles, the scope for DBB is significantly more comprehensive than simply BIM moving towards a digital transformation within the Digital Built Environment. The challenge lies within the demand side, in that this needs to become a more responsible and intelligent actor in this mediation. Current policy does not recognise the (digital competency management) ecosystem explicitly as one of the systems, while IPPR (2017, pp. 3) noted, "*Demand for skills (particularly high-level competences) among employers is low. Employer investment has fallen in recent years and there is a large investment gap with the EU average*". Clear client requirements and value definition in projects have been missing, whilst ineffective old procurement models have been maintained (Mosey et al., 2016). Consequently, clients do not know what competences to demand, nor do they have the capabilities to lead and define the value they need. Therefore, clients themselves require certain competences to fulfil the activities associated with their role.

While post Grenfell has sadly put competence in the spotlight, the forensic lens of competence assurance has not been entirely understood by the sector. The Hackitt Report (2018, pp. 74) states, "*an existing approach to competence which is fragmented, encompassing a range of disciplines and different competency frameworks even within one discipline and without reference to other interacting disciplines. This results in people working within the system, focusing on their individual specialisms without giving due consideration to how their work may interact with the work of others*". Furthermore, "*the JCA [Joint*

Competent Authority] will become more astute at interrogating the work undertaken by these actors, completing the competence loop and ensuring that the skills, knowledge and experience of each of the actors is mutually reinforcing" (Hackitt Report, 2018, pp. 74). This highlights the need for collaborative competency management such that the interactions of work activities, actors (worker), actions, and outcomes can be understood more explicitly in terms of competency and information management.

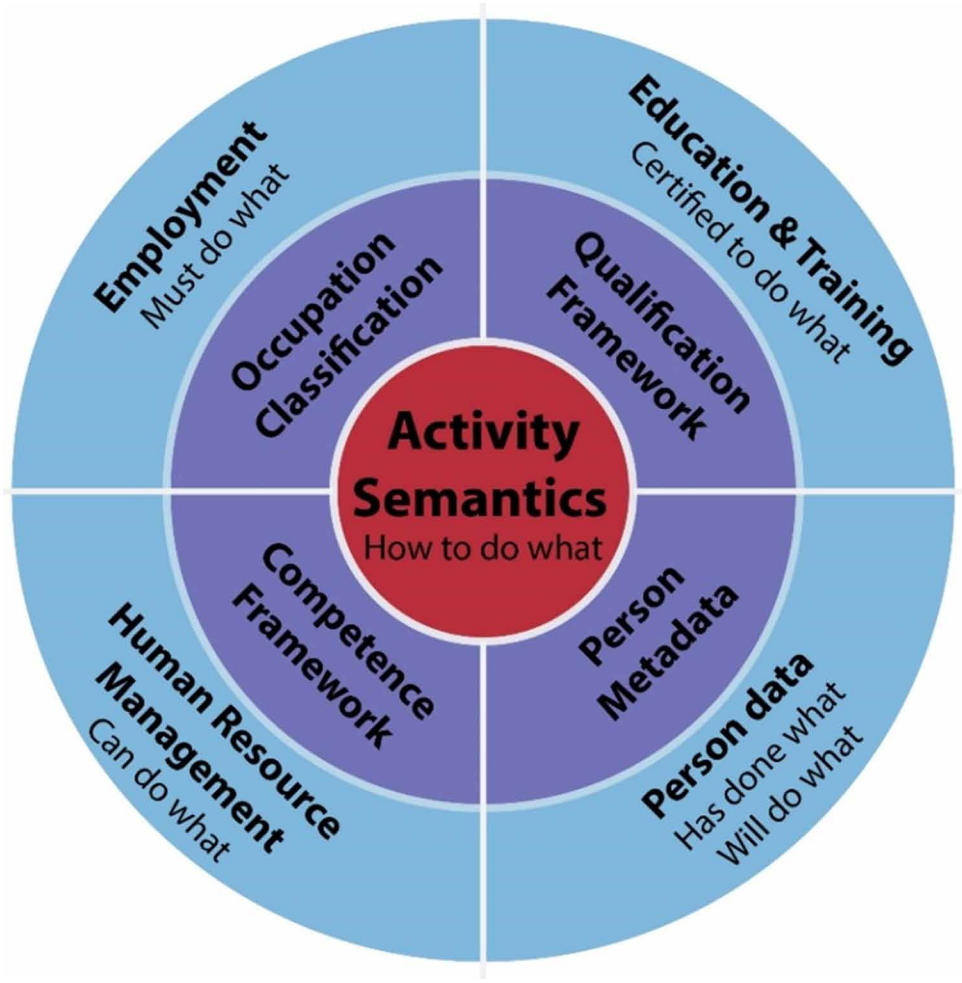
It also implies that, "*competence assurance is set within the context of competency demand and supply mediation; primarily concerned with understanding people@work risks more dynamically within an organisation or ecosystem, where the need, existence, extent, currency, validity, and meaning of competency can be understood more dynamically and securely shared at a granular level and relevant to the next in line process or work activity*" (Carlton, 2019). This is compounded by the lack of knowledge on the impact of a competence gap, shortages, and mismatches on productivity, labour mobility, and diversity. Simply focusing on skills versus all the dimensions of competence, limits diversity. However, the OECD (2017) has started to address this lack of knowledge through its Skills for Jobs Indicators (Figure 3) by understanding competency demand and supply in more granular and multi-dimensional terms. In addition, the UK ONS is also looking at more a granular 'activity' classification of work.

Figure 3. The structure and components of the OECD Skills for Jobs Indicators



Activity Semantics (Zhao, 2017a) is a proven technique that could solve this challenge, but that requires testing, and perhaps adapting, for Digital Built Environment applications (Figure 4). These semantic links would underpin Competency Frameworks and other competence knowledge sources, which in turn, would underpin any Competency Definition. There is increasing overlap of competencies across sectors, professions, trades, roles, and disciplines. A core element must be a digital ecosystem organised around competency frameworks in digital operation, and dynamic context; as opposed to the current traditional static informational model of competence (Zhao, 2019). A fundamental aspect of Competency Demand is Competency Definition.

Figure 4. Adapted from Core of Competency [© Interlates, see Zhao, 2017a]



To define the competency profile required for an activity, we must be able to articulate: *Why that activity is needed (its purpose); What is required (the activity and the deliverables); How the activity should be undertaken, and finally by whom and with whom* (Zhao, 2012). The result is that the value, the meaning of work, and the competences required are all explicitly linked. Value (benefit divided by resources used) is directly linked to productivity. Furthermore, we have the potential to definitively and consistently answer: '*What are we being asked to do?'; 'Why are we being asked to do it?'; 'When do we need to deliver?; How do we deliver?*' Then assemble a competent team based on these requirements to assure the competence of the team to the client (or the stakeholder to whom competence is being supplied). In comparison, the workforce planning on the majority of large built environment projects can be summarised as, 'we need 'n' roles (e.g. project managers)'. The key disruptive factor required is the change in granularity by using the meaning of competency as the computational unit (Zhao, 2012).

If the competency profile required for an activity can be consistently defined then the activity can effectively be matched against the competency profile of an individual or team. This can be scaled up the aggregation of activities required for a role, team, work package, project, organisation, and even across

the whole industry/sector, which could provide far better data to support policy to address the shortage, supply, and mismatch of skills (or competence). 'Skills mismatches' are where individuals are mismatched to their jobs in terms of their competencies, qualifications, or field of study (discipline). The mismatch can be classed as over-skilled/qualified, or under-skilled/qualified or due to skills or competency decay. The difference between the competencies required (for an activity) and the competencies offered (by an individual) is often context dependent. Activities are often cross-disciplinary and cross-role. This will become more prevalent as technology blurs the boundaries between which role (or profession) carries out which activity. However, most training (both initial professional and CPD) is generic, meaning there is a considerable waste (time and money) in the trainee attending courses when only a small subset of the content is actually required. Moreover, unless knowledge/skills is quickly applied and reinforced by experience, the knowledge, skills, and competencies are lost; with skills having a shelf-life of 4.5 years and shortening.

The Competency Profile of the individual is not static; certain competencies can grow and others diminish through a lack of use. This is not immediately obvious to either the employer or the individual. A digital infrastructure that allows the individual to transact on the basis of their competencies would, by necessity, also allow the individual to manage their career. This is important, from a historical perspective, to manage their experience and portfolio, and from a future perspective, to manage their career. Developing a digital infrastructure that places the needs of the individual at the centre of the initiative would be a new paradigm. Upskilling (and reskilling) is the conscious migration of one competency profile to another though education and/or training and/or experience (Zhao, 2018). The competency profile is the pivot of the business logic for competency demand and supply ecosystem stakeholders (Zhao, 2017b).

Competency management is therefore required to identify, assess, match, foresee, control, and assure competency at work. Competency Management is equally applicable to upskilling and reskilling, and both of these are required to address potential future imbalances. Upskilling occurs when an individual is migrating from one competency profile to another within the same profession, e.g. a graduate structural engineer upskills to enable them to become a Chartered Engineer. On the other hand, reskilling tends to occur when someone enters the construction industry from a completely different profession, or moves within the industry from one profession or discipline to another. There are efforts to define competencies across sectors and countries, which overlap such as European Skills/Competences, Qualifications and Occupations (ESCO, 2020). There are also classification efforts of competence topics and subjects such as BIMe (BIMe Initiative, 2020) that is being operationalised through the Quebec Construction 4.0 Initiative (Quebec Construction 4.0 Initiative, 2020) among others. Competency management can potentially target this issue such that these efforts are coordinated across the ecosystem whereby a universal matrix of competencies across ecosystem stakeholders would promote the knowledge of what competencies are required in the labour market.

Competency as Currency in the Labour Market

Productivity concerns the competency of the current and future workforce and effective mediation of competency demand and supply. If individuals and employers have the digital infrastructure within which to transact on the basis of competencies, then competency would become a currency within the labour market. Competencies across all dimensions could become liquidities across the ecosystem. The changing focus from the skilled individual to the composition of competencies that an individual possesses as a computation unit can become the new currency within the market. This could potentially become

a disruptive factor across sectors targeting the pressing issues of a changing labour landscape and the increasing granularity through digitalisation and capabilities, such as activity semantics (Zhao, 2012).

There must be a shift from traditional professional disciplines, roles, and occupations that evolve through silo-based career paths to the support for a career portfolio based on competency management. However, as the current infrastructure is based on the occupational roles, employers only rely on the reputations of educational institutions and professional bodies to assess the competencies of its employees. The current pressing issue in the changing labour landscape is that competent individuals are increasingly responsible for managing their own career in moving from one profile to another. A further key issue is that individuals/employee have no infrastructure with which to effectively transact in the marketplace, or to manage their career portfolio data (Zhao, 2014), and neither is the individual a stakeholder in the changing labour landscape. Competent people are a source of innovation and productivity, and therefore, they are a foundational block in the domain of DBB. However, competent people are usually a lost or unrecognised asset for many organisations. Competency management must therefore be delivered with a people-centric approach (Zhao, 2018).

The key is to make the value and the meaning of work explicit; where attributes of competence in relation to why, how, and what become critical to meaningful work, engagement, and self-actualisation, while improving productivity and reducing risks, as noted by the Skills Review Group (2018). The CPD, professional, trade, and education bodies are currently not fit for this purpose, as the evidence shows (Ball, 2008; Hughes & Hughes, 2013; Morrell, 2015; Uff, 2016; Skills Review Group, 2018). Furthermore, it would empower individuals to take responsibility for their Conscious Competence Evolution and allow employers to both recognise and reward innovation. This needs to be underpinned by a shift from the predominant supply-side policies and interventions to a people-centric approach to improve the mediation and matching of people to meaningful work to improve productivity.

A consensus on foundational definitions and guiding values must be established to begin enabling an alignment on the ecosystem approach to competency management across the built environment. A new digital competency management ecosystem underpinned by the mediation between competency supply and demand would enable a paradigm shift, which would transform the productivity of built environment professionals and organisations of DBB.

Infrastructure Required to Facilitate a New Digitally Enabled Ecosystem

As discussed, the activities, the information required/delivered by the activity, and the competencies to carry out the activity are all intrinsically linked (Simpson & Carlton, 2019). A new digital competency management ecosystem underpinned by the mediation between competency supply and demand, would require a new infrastructure (and underpinning research) incorporating:

- Competence Frameworks to enable consistency and a definition of Competency for a particular activity, function or role;
- The ability for individuals and teams to assess and evidence their personal Competency Profile and to use this to plan their development and careers;
- The ability for organisations and projects to describe their workforce or requirements in terms of Competency Profiles;

- The ability for individuals, teams, and organisations to identify gaps, deficiencies, redundancies (and duplications), and adequacy within their Competency Profiles and, thus, identify how they can best migrate/grow their profiles;
- The ability to provide dynamic career pathways (which should be simple and intuitive to use);
- The ability for education providers to offer courses to enable effective and efficient strategies for the Competency Profile Evolution. This requires competency-based curriculum management;
- The ability for professional institutions and trade organisation to take a more informed view as to the upskilling requirements of their members and to better plan policy, support, and interventions;
- The ability for those responsible for assuring a competent current and future workforce to fully understand and mitigate the risks of gaps and deficiencies in the profile of the workforce. The management and mitigation of such risks would be more dynamic within an organisation and ecosystem where the need, existence, extent, currency, validity, and meaning of competency can be understood and securely shared in a transparent and auditable manner; and
- The ability for government to understand the true imbalances in competence and to plan effective policy to address and imbalances (shortage, oversupply. or mismatch) within the sector and analyse the impact of interventions and policy.

When referring to the digital infrastructure for an ecosystem of competency management we are referring to leveraging an **ecosystem technology architecture** that is dedicated to developing a competency management **platform** that enables a coopetitive e-marketplace of multiple stakeholders, transaction and interaction models, open data and information, and services concerning competency insight, assessment, analysis, planning, development, certification, and assurance.

At times of profound change in the economy, business, professions, and corporations, the disruptive evolution from IT to **ecosystem technology** (ET)[3] has begun. Though success stories are found in multiple sectors from telecom to sales, customer journey to health, ET is still in its infancy. Its application in the new drive for people-centric human resource management (HRM) has bright prospects, particularly as types of work and workers (including dynamic career pathways and upskilling), how work is defined, coordinated, conducted, and assured becomes more complex and dynamic.

Currently, the digital ecosystem competency management infrastructure to enable this does not exist nor the underpinning knowledge base required to underpin this. However, once the infrastructure exists then Competency Analytics (Zhao, 2018) is possible. Competency analytics is a set of technologies and methodologies for competency management, and a decision support system to bi-directionally mediate competency supply and demand. It enables the analysis of the competency state and evolution in order to facilitate a match in competency supply and demand, the fulfilment of competency needs by competency development, competency planning, migration, and assurance. Furthermore, this approach is ideally suited to Artificial Intelligence (AI) and Machine Learning (ML), which could enable unbiased approaches to enable the definition, collection, comparison, extension, and evolution of competences, and is scalable to other contexts (Zhao & Carlton, 2015a, b). Traceability, accountability, and verification/assurance are required to provide confidence in the infrastructure. The AI analytics of competencies present opportunities for DBB organisations to enable an environment in which competent workers are not left without meaningful work, and can transact more effectively in the labour market. In the current infrastructure landscape, the individual is not yet truly a stakeholder.

Moreover, the infrastructure can provide the opportunities to increase the transparency of competency data on individuals and organisations; currently available data is mostly non-transparent, unstructured, and

distributed. In fact, organisations know very little about their workers and the competences that need to be developed to provide future capability. The link between the needs and interests of workers and what they know, can do, and will do, in the context of work opportunities and what value (and to whom) that delivers, is unclear. Demand forecasting in the UK is currently only based on occupational classifications and predominantly survey or statistical datasets. However, an effective ecosystem infrastructure can enable workers to transact effectively in the labour market based on their competencies, and competency can act as a true currency for work, professional development, training, education, credentials, careers, labour planning, certification, and assurance.

PROFESSIONAL DEVELOPMENT LIFELONG LEARNING FOR THE CONSCIOUS COMPETENCY EVOLUTION

Evidence shows that the environment of work is becoming more turbulent, dynamic, and complex; the boundaries of professional occupations and roles are becoming more blurred as architects have started to compete with surveyors and general contractors (Langford & Male, 2008; World Economic Forum, 2018a; World Economic Forum, 2018b). However, competent people are a source of innovation and productivity and are therefore fundamental to the success of DBB. Whether competent people are a lost or unrecognised asset for organisations was debated during the PUN workshops. Workers that better use their skills are more likely to have greater job satisfaction, earn higher salaries, and are more prepared to adapt to changes in the nature of work. Employers benefit from a more productive and innovative workforce, enabling them to maximise business performance and profitability (OECD, 2017a).

The current pressing issue in the changing labour landscape within the built environment is best supported through a digital competency management ecosystem that empowers competent individuals, through the Conscious Competency Evolution, to be responsible for managing their own career. In turn, the Conscious Competency Evolution relies on robust lifelong learning opportunities as well as the enabling digital infrastructure. This aligns with OECD's (2017b) recommendations that stronger incentives must be put in place to encourage lifelong learning among adults and that these initiatives and incentives should be tied to individuals.

In relation to the UK built environment sector, lifelong learning opportunities are typically split into three phases (Figure 5):

Phase 1:

- Pre-18 Formal Education in schools and Further Education Institutes (FEI)
- Level 1: GCSE grades 3→1 or D→G and NVQ Level 1
- Level 2: GCSE grades 9→4 or A*→C, NVQ Level 2, Nat. Dip. L2 etc.
- Level 3: A Level, AS Level, Tech Level, NVQ Level 3, Nat. Dip. L3 etc.

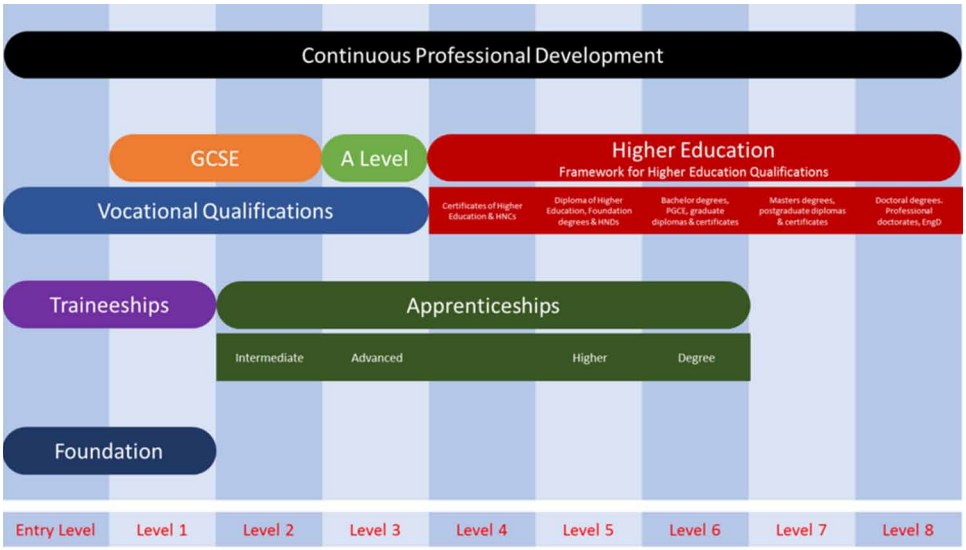
Phase 2:

- Post-18 Formal Education in FEI and Higher Education Institutes (HEI)
- Level 4: HNC, NVQ Level 4
- Level 5: HND, NVQ Level 5
- Level 6: Bachelor's Degree, NVQ Level 7
- Level 7: Master's Degree, NVQ Level 8
- Level 8: Doctorate

Phase 3:

- Continued Professional Development (CPD) and re-qualification

Figure 5. Phases of lifelong learning



When examined through the lens of competency, both the Post-18 formal education and CPD phases of lifelong learning are found to be out-of-date, siloed, and not fit-for-purpose. The education system is still focused on producing a workforce for previous industrial revolutions, whilst industry attempts to embrace and embark on Industry 4.0; the forth industrial revolution.

Pre-18 Formal Education

In terms of Pre-18 formal education and the development of digital competencies to facilitate the sector's digital transformation, much more needs to be done to address the poor image of the industry and prevent the talents of the next generation from being siphoned from the built environment professions to other more perceived attractive sectors, e.g. big tech, medicine, law, etc. Key areas for action include:

1. improved career advice to address the awareness and recognition of the construction/built environment sector as a viable proposition for a professional career;
2. initiatives that deliver construction/built environment specific curriculum and qualifications, e.g. Design Engineer Construct!® (DEC, 2020);
3. greater involvement and engagement of construction professions with schools to support the previous areas for action and support improving the image of the construction/built environment sector.

In this context, a much deeper rethink is required on whether Pre-18 formal education is actually setting students up to get the most from their continued learning opportunities at degree level and beyond. National standards and national curriculum, enforced by high-stakes testing, can at best teach learners

what is prescribed. As a result, learners talented in other areas never have the opportunity to discover those talents, while those learners with broader interests are discouraged and not rewarded. The system results in a population with similar skills in a narrow spectrum of talents. However, particularly in today's society, innovation and creativity are needed in many areas; some as yet undiscovered. Primary education in particular, is based on a Victorian model that is cheap and efficient, rather than one based on educational reasons. An example is the fact that primary schools have remained stuck with the system of generalist teachers, the class teacher, rather than the more expensive model of subject specialists, as happens at secondary level (Baker, 2020).

Post-18 Formal Education

An undergraduate degree is a good vehicle to provide a dense package of pre-requisite knowledge prior to embarking on a career. However, the Royal Academy of Engineering (2007) stated that, whilst the industry is generally satisfied with the engineers it recruits, there are concerns about the ability of graduates to apply their knowledge to real industrial problems. The PUN report highlights that it had become more acute in recent years and was identified as one of the skill shortages impacting business growth. This raises the question as to whether HEIs were able to keep up with the industry's fast pace of change, with employers reporting they are not in a position to recruit graduates with the relevant digital competences. Furthermore, HEIs are perceived to reinforce the silo mentality of industry, the nature of which is widely seen as a significant contributor to the lack of productivity within the sector. However, the system of education in the health sector could provide useful lessons to learn from, e.g. trainee doctors undertake a degree in general medicine prior to specialising in a particular branch. In addition, built environment specific courses should be split into a 'generalist' undergraduate degree followed by a 'specialist' post-graduate level. While there is much merit in this as an approach, it is also recognised that the specialist colleges in medicine are just as impacted by a silo mentality as the construction sector. This has led to some calls for a new medical 'specialism' that takes a systems integration approach to coordinate the different specialists. Similarly, Cook and Chatterjee (2015) suggest that there is an increasing need for interdisciplinary working and leadership capabilities in the built environment.

It should be noted that the silo mentality exhibited by HEI's is a direct response to the accreditation of their courses by specific professional intuitions. Furthermore, it is accepted that HEIs have limited scope for innovation if their courses are to be accredited, while the accreditation criteria defined by the professional bodies has, in the main, lacked incorporating requirements for digital competencies. Whilst there is desire to innovate, the procedures for major change to programmes and modules results in a risk-averse strategy with considerable pressure to meet accreditation requirements of the various professional bodies within the constraints of the current system. In addition, this is further exacerbated by the lack of technologies in curriculum management, where competence demand can be understood more explicitly. Many HEIs pursue both teaching and research agendas and traditionally recruit research professionals to ensure they meet the requirements for the Research Excellence Framework (REF). *However, will the introduction of the Teaching Excellence Framework (TEF) mean the same focus on teaching and learning in the future?*

This is further reinforced through promotion routes that favour those with research success in winning grants and the amount of published works. In many HEIs, research specialists are also expected to deliver teaching modules; whilst this may be acceptable for theoretical modules, built environment courses often have significant elements of vocational training that require knowledge and experience of current and

evolving industry practice. As we move towards a more digitally-enabled future, the 'human-centric' competencies involving multi-disciplinary teamworking, creativity, innovation, and design will become increasingly more important as the traditional technical aspects will be taken over by AI and ML. The pressure from industry to increase these aspects on courses are met by the constraints of suitable spaces, staff-student ratios, and the competence and experience of staff to lead such activities, in addition to meeting the accreditation requirements of the relevant professional bodies. Therefore, it is important to consider that there needs to be alignment between the transformation of built environment education and the accreditation of built environment programmes in order to prepare students with the necessary entry-level competence for their future careers, and to build capacity for a transforming industry (Farmer, 2016), i.e. future proofing.

Learning outcome frameworks such as the UK BIM Framework's (UKBF, 2020) and potential work by CDBB to establish digital competencies required by new graduates to the built environment professions aim to facilitate consistency in the development and delivery of digitally-enabled built environment training and education. Similarly, the UK BIM Academic Forum (BAF) proposed an academic roadmap to a longer-term vision that embeds digital construction learning at the appropriate levels within discipline-specific HE undergraduate and postgraduate education (BAF, 2013) and further work continuing to break down and establish the potential learning outcome requirements at each level of HE (i.e. 4-7). However, adopting such learning outcomes/frameworks within education curricula also requires a change to the culture and mindset of academics alongside the development of their competence to drive change in the current curricula and align with the needs of future generations of learners (BIM2050, 2014). As is similarly evident in industry, the understanding, acceptance, and importance of digital transformation amongst HE academics within the built environment, engineering, architecture, etc. is still considerably low (NATSPEC, 2014, 2015, 2016, 2017; 2018; Underwood, 2014; BAF, 2015). Therefore, changing the culture and mindset that exists among many academics poses a significant challenge to the transformation of built environment education from one that currently reinforces a silo mentality and continues the development of disciplinary-specific (silo-minded) professionals; driven by the accreditation requirements (BIM2050, 2014). Moreover, this is still considerably short of a digital ecosystem that would facilitate demand-led competency-based curriculum management. In addition, there is the question of how we ensure the academics who develop and deliver courses also assure their own competence; academics similarly require, and have the need for a conscious competence evolution as much as industrialists.

Amongst the case studies that demonstrate an exemplary engagement between industry and universities (RAEng, 2010), there is a lack of data to indicate whether this is a consistent story or whether, for some, interactions only occur through occasional meetings with their Industrial Liaison/Advisory Committees. The question of whether universities should play a more significant role in the lifelong learning journey beyond the provision of degree programmes was explored. This is not to say that HEIs have little to contribute to lifelong learning, but rather the way the learning provision is consumed is at odds with the evolving requirements of a highly agile and digitally connected built environment workforce. While digital construction is becoming more widespread across various levels of education, in the main, the approach is still tending to be ad hoc and without consistency. Furthermore, rather than being set as a strategic objective at a school/department or institutional level, this is being driven by individual academics or schools/departments that have a particular interest in the area and recognise its importance in the education of current and future professionals, as opposed to being demand-led, adaptive to the demand, and driven in a work context, i.e. bottom-up (Underwood, 2014; BAF, 2015). However, the

introduction of Degree Apprenticeships is a welcome concept to bridge the gap between industry and academia (Universities UK, 2019). It remains to be seen as to whether Degree Apprenticeships deliver the potential for a true collaboration between industry and academia in the upskilling/reskilling of the workforce, or simply provides a day-release course under another name.

CPD and Professional Institutes/Institutions

Professional Institutes/Institutions have evolved in a manner that reinforces the silo thinking within the Built Environment. This is a direct response that both protects their members and acts as a body of knowledge to serve their members (Egan, 1998; Wolstenholme *et al*., 2009; Morrell, 2015; Mosey *et al*., 2016; All Party Parliamentary Group for Excellence in the Built Environment, 2017). The exigencies of DBB transcend the objectives of professions and demand a broader view on the evolution of professionalism as professions create cognitive frameworks within their jurisdiction to only seek control (Hughes & Hughes, 2013).

Furthermore, the Professional Institutes/Institutions set the requirements for the degrees they accredit both directly and, for some, indirectly through their input to the UK Standard for Professional Engineering Competence (UKSPEC). As such, they influence the FEI and HEI provision of lifelong learning, as well as the provision of Continued Professional Development (CPD). CPD is the means by which the Professional Institutes/Institutions assure that their members remain competent, as beyond the Initial Professional Review, there are no further checks. However, the ICE Skills Report (ICE, 2018) states that the current CPD model is not-fit-for assurance, and that "*civil engineers who fail to keep abreast of changes affecting their areas of activity are simply unfit to practice*". The challenges that the ICE and other Built Environment Professional Institutes/Institutions face are not unique, as CPD is problematic in multiple ways:

- CPD is not typically competence-based, either in assessing the requirement for CPD, or in demonstrating how CPD has made a discernible difference to the competence of the receiving individual;
- CPD requirements are specified as a number of days, meaning that quantity is valued, rather than quality (or even applicability);
- There are no means of comparing one CPD provision over another; and
- There is a lack of consistency and transparency that would limit the effectiveness of mandatory auditing.

Therefore, CPD requirements should be urgently reviewed to establish a more robust system that ensures a member's qualification remains relevant to their work and aspirations and up-to-date throughout their professional career. Professional Institutes/Institutions and trade organisations are the key players that specify both the technical requirements for lifelong learning and the criteria by which this can be assessed for suitability. However, there are too many voices and the silo nature appears too entrenched to provide any industry-wide leadership in this area. The multiplicity of institutes/institutions and their nature means they cannot agree on a common issue even when the public good represents a common struggle within the industry. This high fragmentation creates challenges for the Construction Leadership Council in addressing multiple voices; consequently, it takes a neutral position that leads to no change. The professions have been poor at collaboration at an institute/institutional level (Morrell, 2015), and the characteristics of their business models are contradictory to what the Construction Leadership Council

hopes to achieve. Thus, Hughes and Hughes (2013) and Morrell (2015) have called for a significant reassessment of the importance of professionalism in the society. However, there are positive signs of change, as seen in the recent Hackitt Implementation Plan, that engineering institutes/institutions are beginning to collaborate in order to address the issue of competency assurance. Sectorial collaborative competency management is the obvious way forward, but there is no underlying (digital) infrastructure to enable this.

CPD Provision

The provision of CPD is fragmented and disjointed. Furthermore, there is no consistent framework, which in turn, means that it is impossible for individuals to compare one provider's course against another when they have identified specific competence development requirements, and for providers to develop courses tailored to specific and identifiable gaps in both current and emerging competence. This is not to disparage CPD provision, but rather, to illustrate why it is currently not-fit-for purpose. If the underlying infrastructure to facilitate comparison does not exist, then providers cannot be blamed for their attempts to respond to market forces. The lack of a digital infrastructure and ecosystem to support this infrastructure is problematic in that many course participants are only attending for a fraction of the content that is relevant to their specific requirements. As different attendees have different requirements, CPD provision often takes a 'shotgun' approach in trying to cover a wide range of topics with the hope that all attendees will take home something they find useful. There are currently no real examples of dynamic, competency-based CPD planning, although the ICE has undertaken some foundational work in this area (Zhao and Carlton, 2015a, b, 2019).

It is well documented that, unless an individual applies the skills and knowledge they gain from a training course, both immediately and consistently in their day-to-day activities, their knowledge and skill retention decays. Therefore, it is questionable as to whether any CPD that is not directly relevant to their day-to-day activities is of benefit. CPD provision is usually provided in multiples of half days, with many courses taking a full day. This time actively discourages individuals who are sole traders and/or from micro SMEs, as the time to attend courses is taken directly from their fee-earning capacity. However, a significant proportion of the workforce of the built environment (both in terms of construction and professional services) is comprised of micro SME/sole traders (BIS, 2013; Designing Buildings Wiki, 2019). Moreover, it is unclear as to what real effect or change will be brought about by the mandatory CPD auditing and reporting required from January 2019.

Unlearning: Selecting an Alternative Mental Model/ Paradigm for Conscious Competency Evolution

Ever since the publication of Peter Senge's "*The Fifth Discipline*" 25 years ago, organisations have sought to become 'learning organisations' that continually transform themselves. In our era of digital disruption, this goal is more important than ever. However, making real progress in this area, even for the best organisations, still presents a significant challenge. A key problem is that organisations have focused on the wrong thing. The problem is not learning, but in fact, unlearning. In every aspect of business, we are operating with mental models that have grown outdated or obsolete, from strategy to marketing to organisation and leadership.

To embrace a new logic of value creation by embracing all that digital allows we have to unlearn the old logic to facilitate digital transformation. The misconception is that unlearning is about forgetting, but instead, it is about the ability to choose an alternative mental model or paradigm. When we learn, we add new skills or knowledge to what we already know, whereas when we unlearn, we step outside the mental model in order to choose a different model. Therefore, in a time of digital transformative change and empowering competent individuals to be responsible for managing their own career through the Conscious Competency Evolution, individuals need to be conscious of their mental models and ambidextrous in their thinking (HBR, 2016).

Organisational Performance and Learning

New approaches or methods that emphasise a 'data-to-learning-to-action' process (Flinn, 2018) that focuses on improved evidence-based decision making and continuous performance improvement need to be considered as part of the upskilling agenda. This approach recognises the key to improving business performance is improving decision-making. Furthermore, it is the decisions that are aligned to the most important drivers of the value of an organisation that make the difference. There is great claim of the power of big data but the key is how it helps improves decision-making. There is no intrinsic value in data unless it serves as the basis of enhanced learning or has the potential to (including unlearning), and then to action. Learning is not just a human endeavour it is learning by humans and machines. It is NOT all about data but it is ALL about decision-making and learning. Businesses that are not knowledge, learning, and decision-intensive are much more likely to be automated and routine.

WHAT NEEDS TO HAPPEN NEXT?

The focus of the work presented in this chapter explores how we create and support a digitally-enabled, agile, competent, and ultimately, productive workforce and determine the key questions that need to be addressed if DBB is to both provide return on investment, and succeed as the catalyst for evolving the manner in which we conceive, plan, design, construct, operate and interact with the built environment. The vision is that we need to imagine a digital competency management ecosystem where all stakeholders are incentivised to work together in coopetition to create, capture, infer, interpret, specify, integrate, accredit, apply, use, monitor, and evolve competence as a working asset just like any other data asset. Moreover, this needs to be in a consistent, objective, explicit and scalable manner; with end2end transparency and traceability for all stakeholders that overcome the challenges of competency management. *With an increasing overlap of activities and competences across sectors, professions, trades, roles, and disciplines, a core element must be an ecosystem organised around digital infrastructure of competency frameworks and other knowledge sources of competence, so that competency frameworks are in digital operation and dynamic context; as opposed to the current traditional, static informational model of competence.*

Table 1 presents the fifteen key research (and subset) questions derived to guide further research. By addressing these questions in future research activities, the pedagogical and upskilling/reskilling aspects, through the vision outlined above, DBB could be effectively realised. The questions are structured to demonstrate:

- Urgency of the research needed (from the completion of the CDBB PUN) in relation to the immediate and short-term, medium-term of three to five years, and long-term of five to ten years, based on the previous research being achieved;
- Current level of maturity of research (i.e. the current research knowledge-base in terms of being novel or some level of research existing);
- Ascertaining whether the proposed further research activities require industry, academia, and other complementary, but important, institutional stakeholders, who relate to the value proposition to work together. From previous experience, it can be clearly demonstrated that, when the cooperation extends beyond a single industry-breaking institutional silo, this leads to the achievement of a more successful outcome.

Based on the key research questions from the PUN network, the following provides a summary of the key findings and associated recommendations:

- Central to productivity are people; the competency of the current and future workforce, which need to be treated as a working asset just like any other data asset in the built environment.
- The purposeful language of Dame Judith Hackitt concerning competence, competent, competency, and competency assurance has not been fully adopted by the sector.
- Competence is not just about competence frameworks; there are other sources of knowledge of competence as well as competency data (unstructured and distributed), which we also need to digitise. Competency does not currently act as the unifying currency of the labour market. Occupations are used as a proxy for demand and qualifications as a proxy for supply, which is no longer granular or multi-dimensional for the dynamic world of work.
- There is increasing overlap of competencies across sectors, activities, professions and trades, roles, disciplines, etc. and this will only increase with automation, digitalisation and increased regulation. A new model for the post professional society is required.
- There needs to be recognition that knowledge of, and data about, competence is for machines as well as humans
- Boosting productivity also comes from the effective mediation of competency demand and supply; skills imbalances are linked to low productivity.
- A digital competency management ecosystem can facilitate the mediation of competence demand and supply in DBB; people-centred, community-based that connects all the inter-dependent stakeholders in coopetition within and across sectors, occupations, and disciplines. A digital marketplace facilitating and mediating supply and demand of data, information, and knowledge about competences, occupations and roles, disciplines, upskilling/reskilling and learning, qualifications, certification, standards, regulations and policies.
- The upskilling/reskilling of people and their competencies is simply the evolution (acquisition, application, appreciation, and depreciation) of one competency profile to another. One off static qualification or certifications are no longer fit for purpose.
- Upskilling/reskilling must be competency based and granular enough to address change to work duties and activities, and how work is conducted; across all dimensions of competence.
- Lifelong learning journeys of individual learners must be relevant to competency demand and the evolving competency needs of individuals as well as industry.

- In relation to the pedagogy and upskilling/reskilling aspects in the context of lifelong learning and achieving the long-term vision outlined, the logical order for the sector would be to define what upskilling/reskilling needs to mean in terms of competence, and in particular, the phrase, conscious competence evolution in the first instance, followed by then defining, creating, and growing the digital competency management ecosystem to support upskilling/reskilling, and enable the conscious competence evolution, and finally, define the pedagogy that best suits the required upskilling/reskilling.

CONCLUSION

This chapter has presented a proposition for the digital transformational change of people and their competencies to facilitate the change required to enable the built environment to evolve into the 21st Century and the future. Change has begun with Government mandates generating a number of BIM training activities, as an important first step. However, continued success will require an evolved upskilling/reskilling philosophy to develop a digitally competent and agile workforce capable of supporting the emerging digitally-enabled processes, purpose driven information flow, and the collaborative behaviours that underpin them.

It is vital to ensure that individuals, teams, and organisations have the necessary appropriate knowledge, skills, abilities, experience, behaviours, and attitude at work, i.e. 'competence', to carry out tasks/activities they are appointed to perform. It is also vital for clients, when appointing individuals, teams, and organisations, to undertake construction operations, to ensure they are 'competent' to be able to conduct the work appropriately. The chapter has highlighted a need for training and qualification systems that need to be driven by dynamic competency demand data.

Whilst there is continued investment being targeted at more general digital literacy and skills frameworks, through the DfE, CITB, CDBB, etc. such initiatives still take a classical information model approach to competency frameworks when a systems model is required, i.e. a digital competency management ecosystem. It is imperative that this systems approach is adopted to enable the sector to demonstrate that successful projects are characterised by the right people, making the right decisions, at the right time, using the right information. Furthermore, 'competence' ensures there are the right people available to specify the information required to make those decisions, and correctly interpret the received information. It can also be argued that productive work only occurs when competent people specify the work that must be done, which is in turn, carried out by other competent people. The productivity of people comes from effective mediation between competency supply and demand, and enabled by the flow of appropriate and correct information.

Table 1. Key research questions & direction'

	Question *(No.)*	Impact	Maturity (of research)	Lead by
Short-term	How do we design/manage/implement a 'collaborative competence management' approach that enables/facilitates competence as a currency in the labour market? *(Q5.)*	HIGH	NOVEL	JOINT
	The following subset of questions were determined necessary to answer this wider question: There is a lack of consistency, even understanding, of the terms 'competence', 'competency', and 'competent' within the built environment sector. Without this, any work on 'competence management' and 'competence development' will have a limited effect. What is the best way of redressing this? *(Q1.)*	HIGH	MEDIUM	JOINT
	Who are the stakeholders that any built environment sector will have to engage with in terms of 'competence management' and 'competence development'? How are they interconnected with other stakeholders? What is their sphere of influence? *(Q2.)*	HIGH	MEDIUM	JOINT
	The general consensus is that 'competence' is activity based, not role based, yet there is no consistent definition/ontology relating to the activities that contribute to the built environment. Thus, how can we define/develop a flexible/extensible ontology that describes the activities of the built environment? *(Q4.)*	HIGH	MEDIUM	JOINT
	If productivity is linked to the competence of individuals within the market place and, in particular, the mediation of competence supply and demand, then the low productivity of the built environment sector is likely to be a result of this not happening. Therefore, why is this not happening? And what is required to circumvent the blockers. *(Q10.)*	HIGH	MEDIUM	JOINT
	How does curriculum development need to adapt to align to a 'collaborative competence management' approach? *(Q7.)*	HIGH	NOVEL	JOINT
	If the fundamental question is about empowering individuals to consciously evolve from one competence profile to another, then what are the infrastructure, technology and processes required to facilitate/enable this? *(Q11.)*	HIGH	NOVEL	JOINT
Medium-term	'Upskilling' typically implies a 'skills gap', but may also imply a natural result of 'skills decay', where competence is a function of education, skills, experience, and behaviour. The general consensus is that the built environment sector has a 'competence mismatch'. So what is 'upskilling' in the context of an 'individual's competence development' and 'competence management'? *(Q3.)*	HIGH	MEDIUM	JOINT
	The UK suffers from poor data relating to its labour force. To address this, what do we need to measure and how do we measure it? How does this relate to competence management/ competence development? *(Q6.)*	MEDIUM	MEDIUM	JOINT
	How can we ascertain the likely return on investment of moving from a skills gap philosophy to a conscious competence evolution philosophy? What do we need to measure and how can we measure it? *(Q12.)*	HIGH	NOVEL	JOINT
	For a conscious competence evolution to emerge then 'unlearning' is an important part of evolving. In this context, what do we understand as unlearning? And how do we 'teach' this? *(Q13.)*	MEDIUM	NOVEL	ACADEMIA
	How does the conscious competence evolution lead to agility and resilience in the workforce? *(Q14.)*	HIGH	NOVEL	ACADEMIA
	How does an individual competence development approach allow individuals displaced by the new industrial revolution to thrive and contribute to society? *(Q15.)*	HIGH	NOVEL	JOINT
Long-term	How does education need to adapt to become 'demand led' and 'competence based?' Is our current university education fit for purpose? If all education is demand led, how do we educate the future 'pathfinders'? Should educators be competent in the subjects they are teaching? *(Q8.)*	LOW	NOVEL	JOINT
	What and how to enable individuals to thrive in the workplace and access opportunities for more meaningful work? What are the means to enable competent and honest individuals to distinguish themselves from incompetent and dishonest individuals? *(Q9.)*	LOW	MEDIUM	JOINT

In order to be successful, we should ensure that we reach out beyond traditional built environment professionals and include experts from other domains and industries with new propositions, e.g. manu-

facturing, finance, IT, agile business practice, and competence management. The learning from other industries should help in the design and development of the digital competency management ecosystem. This learning has a critical function as it should set out the norms of interactions between individuals and organisations, and organisations with other organisations (many-to-many relationship of competency demand and supply). Process and technology are the means by which these interactions take place. This is even more important when considered with the growing organisational complexity of the Digital Built Environment. This chapter has shown that such complexity leads to high uncertainty, and taken with the central role of collaboration, the proposed ecosystem approach being defined in this chapter becomes more important. A multidisciplinary approach to competency-based management across sectors, disciplines, professions, etc., matters more than targeting productivity improvement through rapidly changing digital technologies.

This chapter has placed competence at the core of any new initiatives to increase productivity in the (digital) built environment. In addition, the need to build competency profiles of individuals to understand competency supply, and to conduct a more intelligent analysis of work and the value of work to understand demand and produce target competency profiles, has been discussed. Competence is not just about knowledge and skills, but is the application of a combination of such dimensions as knowledge, skills, abilities, experience, behaviours and attitude at work, if we are to see productivity gains of the like set by global governments. Ultimately, all people interacting in the built environment need 'competence assurance' (as recommended by Hackitt (2018)), meaning that the sector requires the capability (including technologies and processes) to intelligently manage competence, people, and work. However, one of the key challenges of this is: *Do employers actually know enough about the competence(ies) of their workers?*

In understanding the challenges posed in this chapter, it can be concluded that there are two fundamental questions to be addressed:

1. What does upskilling/reskilling look like through the lens of competence and competency evolution?, and
2. What is the (digital) infrastructure required to support the mediation of competency supply and demand and the fulfilment of competence needs by competence development, planning, migration and assurance?

The focus of the work presented has highlighted the need to create and support a digitally-enabled, agile, competent, and ultimately, productive workforce, and determine the key research questions that need to be addressed to both provide return on investment, and succeed as the catalyst for evolving the manner in which all conceive, plan, design, construct, operate, and interact with the built environment. The vision is to imagine a digital competency management ecosystem where all stakeholders are incentivised to work together in coopetition to create, capture, infer, interpret, specify, integrate, accredit, apply, use, monitor, and evolve competence as a working asset just like any other data asset. Moreover, this needs to be in a consistent, objective, explicit, and scalable manner; with end2end transparency and traceability for all stakeholders that overcome the challenges of competency management. There is an increasing overlap of competencies across sectors, professions, trades, roles, and disciplines. A core element must be an ecosystem organised around digital infrastructure of competency frameworks, competency frameworks in digital operation, and dynamic context; as opposed to the current traditional informational model of competence.

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KEY TERMS AND DEFINITIONS

Capability: The complex combination of an appropriate set of competences in order to achieve a specific organisational objective(s). It emphasises the key role of strategic management in appropriately adapting, integrating, and in re-configuring the internal and external organisational skills, resources, and functional competences in a changing environment (Teece et al., 1997).

Competence/Competence Frameworks (CF) or Models: Are designed with respect to an organisation, function, or occupational activity. CF are textual descriptions, but they are designed along conceptual dimensions, e.g. knowledge, skills, abilities (KSA) or other attributes such as behaviours, etc. Therefore, a CF can be a collection of competence dimensions or KSAs with relationships, levels, and other attributes such as importance, currency, roll-up rules. Competence Frameworks are typically designed to deliver a breadth of outcomes relating not only to training, but also talent management, professional development/CPD, appraisal, performance review, organisational design, and development, etc.

Competence(s): 'A capability demonstrated in an activity at work (who can do what, why, how, where, when, with whom, with what'). It is an ability to conduct an activity or perform a task for a

professional duty1. Competence has multiple dimensions, expressed in such terms as duties, abilities, skills, experience, expertise, aptitude, knowledge, education, qualifications, behaviour, values, interests and attitudes'. Competence is multi-dimensional, multi-faceted and context dependent and increasingly many competences overlap sectors, disciplines, professions, and roles in the dynamic world of work. But, they all refer to, implicitly or explicitly, to activities at work (Zhao, 2017a, 2017b).

Competency Analytics: A set of technologies and methodologies for competency management. It is a decision support system for bi-directionally mediating competency supply and demand. It enables the analysis of competency state and evolution in order to facilitate the match of competency supply and demand, the fulfilment of competency needs by competency development, competency planning, migration and assurance.

Competency(ies) (in Ecosystem Context): A competence profile; a set of competences associated with a person, team, task, role, project, profession, service, process, practices, courses, publications, and policy (Zhao, 2017b).

Competency Assurance: Set within the context of competency demand and supply mediation and is primarily concerned with understanding people@work risks more dynamically within an organisation or ecosystem where the need, existence, extent, currency, validity, and meaning of competency can be understood and securely shared at a granular level and relevant to the next in line work activity, HRM/ people processes (e.g. workforce planning), individual development/career planning, CPD, re-certification/ licensing, or in response to a specific competency assurance request (Carlton, 2018).

Competency Management: Competency and its management concerns identifying, acquiring, assessing, matching, foreseeing, and assuring competency at work, in order to mitigate its demands and supplies including minimising risks.

Digital Competency Management Ecosystem: A digital community platform of inter-dependent stakeholders in cooperation within or across sectors and occupations. It is an electronic-market of services facilitating and mediating supply and demand of data, information and knowledge about competences, professions, trades and roles, disciplines, learning opportunities, qualifications, best practices, standards, regulations and policies. It concerns structural innovation.

Reskilling: In terms of re-skilling, the main context is migration – planning the transition and moving to a new activity, role, job, discipline, profession, sector which may require new competences and unlearning. It terms of transition it often concerns both stocks (personal, social and institutional resources) and flows (moving in, moving through, and moving on).

Skill: The functional ability the person or agent has to perform activities and actions.

Skills Gap: Occurs when businesses do not have sufficient staff with the required skills in their existing workforces and willing to move to the next role or job or activity.

Skills Mismatch: Are where individuals are mismatched to their jobs in terms of competences, or qualifications or field of study (discipline). The mismatch can be over-skilled or qualified or under-skilled or qualified for example.

Skills Shortage: Are where businesses have difficulty finding suitably skilled individuals from the potential pool of available recruits or talent pool at the going rate of pay and working conditions. They can be broadly defined in terms of an inadequate supply of workers in high-demand occupations and/or inadequate supply of skills required to perform the tasks associated to such occupations.

Skills Surplus: Are characterised by a relatively high supply and low demand for a given skill (often identified by high unemployment). One can't consider skills gaps or shortages without considering surplus.

Upskilling: Upskilling concerns the progression from one competency profile to another. When considering Professional Upskilling the key questions is 'upskilled to do what to what level, why, where, when, with what, with whom etc.? This may concern learning new competences or ways of working.

ENDNOTES

[1] Skills is the current language of the sector and used as a proxy definition or abstraction for competence when in fact skill is a dimension of competence.

[2] Up-skilling. re-skilling or de-skilling is the current language of the sector where, for example, upskilling is typically defined as a process or event of learning new skills (i.e. often only application) rather than an evolution (acquisition, application, appreciation & depreciation) from one competency profile to another (dynamic, multi-dimensional, context-dependent).

[3] 'Adopting an ecosystem view of business technology' (McKinsey, 2017).