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Evolve or Die:
**Transforming the productivity of Built Environment
Professionals and Organisations of Digital Built Britain
through a new, digitally enabled ecosystem underpinned
by the mediation between competence supply and
demand**

Pedagogy and Upskilling CDBB Network

Report

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Executive Summary

The Pedagogy and Upskilling Network (PUN) is one of a number networks of collaborators for the Centre for Digital Built Britain (CDBB); members are drawn from research, practice and other areas, and contribute their work with the aim of:

1. Proposing the capabilities needed for the UK to deliver and benefit from Digital Built Britain, and identifying the enabling research to deliver those capabilities;
2. Describing the state of the art and leading-edge practice of today;
3. Building communities of people interested, and able to participate, in future research, demonstrator and pilot projects.

PUN was commissioned to explore and address the research questions around how we create and support a digitally enabled, agile, competent and ultimately, productive workforce.

This report presents the outcomes of the network in terms of the key questions that need to be addressed for Digital Built Britain (DBB) in order to provide both a return-on-investment and to succeed as the catalyst in evolving the manner in which the built environment is conceived, planned, designed, constructed, operated, and interacted with.

In summary:

- The successful evolution of the industry is complex and fragmented. Furthermore, there is little evidence of industry wide initiatives that support the people-centric focus required to successfully deliver change on a scale that is unprecedented.
- Although BIM Training is an important first step on the Digital Transformation journey, success will require an evolved upskilling/reskilling philosophy.
- While the 'Golden Thread of information' is likely to be achieved through 'technology' and 'process', and consequently may be easier to achieve than 'competence', Competency provides a much greater challenge even though it is enabled through technology.
- The impact and implications for the many stakeholders that comprise the ecosystem of the Digital Built Environment need to be assessed to respond to the key challenges of Digital Built Britain by reaching out beyond traditional built environment professionals.
- The mediation of competency supply and demand directly impacts productivity as much as the flow of timely and appropriate information, i.e. through information transactions. However, the proxies used for competence supply and demand are no longer either granular or dynamic enough for the changing world of work.
- Competence assurance requires the capability (including technologies and processes) to intelligently manage competences, people and work activities.
- Initiatives focused on training alone will not solve the productivity challenges; therefore future initiatives need be considered that address BOTH competency supply and, in particular, competency demand.
- The competency profile of the individual is not static, whereby certain competences can grow, while others diminish through a lack of use. Upskilling and reskilling is the conscious migration of one competency profile to another through education and/or training and/or experience. Furthermore, the competency profile is the pivot of business logic for both competency demand and the supply ecosystem stakeholders.
- Furthermore, a conscious competency evolution relies on robust lifelong learning opportunities and infrastructure.

- Competency management is required to identify, assess, match, foresee, control and assure competency at work; this means addressing potential future imbalances (gaps, shortages and mismatches).
- A new digitally enabled ecosystem underpinned by the mediation between competence supply and demand would require a new infrastructure (underpinned by research), which does not currently exist. Developing an infrastructure that places the needs of the individual at the centre of the initiative would be a new paradigm.
- Furthermore, the infrastructure would enable competency analytics for competency management; this would enable the bi-directional mediation of competency supply and demand.
- To address the productivity issue, a more effective mediation of competency demand and supply (to decrease mismatches) is required, and a more granular view of work activities and competences (i.e. more multi-dimensional) to cope with the dynamic world of work and increased digitalisation.
- In terms of pedagogy, there is still a considerable lack of ecosystem to facilitate curriculum management to ensure that it is competency-based and demand-led. In addition, it is essential that academics also assure their own competence as they have as much a need of a conscious competency evolution as industrialists.
- The lack of a digitally-enabled infrastructure and ecosystem is also problematic for competency-based professional development through lifelong learning, including CPD, training, etc.
- With such an infrastructure and ecosystem, competence would become currency within the labour market and competencies across all dimensions could become liquidities across the ecosystem. This potentially becomes a disruptive factor across sectors targeting the pressing issues of a changing labour landscape and increasing granularity (e.g. team and task-based work) resulting from digitalisation.
- Defining the pedagogy that best suits the upskilling required depends on first defining what upskilling needs to mean in terms of the conscious competence evolution, and second by developing an ecosystem to support a competence-based approach to upskilling that effectively enables the conscious competence evolution.

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1. Introduction

The Pedagogy and Upskilling Network (PUN) was commissioned by the Centre for Digital Built Britain (CDBB) to explore and address the research questions around how we create and support a digitally enabled, agile, competent and ultimately productive workforce.

Over the last few months the challenges, opportunities and barriers have been assessed through workshops and literature reviews resulting in a number of key questions that need to be addressed if Digital Built Britain (DBB) is both to provide a return on investment and to succeed as the catalyst for evolving the manner in which we conceive, plan, design, construct, operate and interact with the built environment.

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. A report by McGraw Hill (2014) states that 61% of ‘highly engaged Contractors’ and 41% as an average of the sector rate training in Building Information Modelling (BIM) as a high priority. However, the BIM Survey (2017) by the Institution of Structural Engineers reported that 38% of respondents indicated their firm provided poor or no training. Of those receiving training, only 10% reported that principal staff and/or directors were being trained in BIM; the majority were either technicians or graduates. It is a reasonable statement that BIM training can either mean ‘learning to use technology’ (the type often undertaken by junior staff) or ‘process focused’ with the majority based strongly on the PAS 1192-2:2013 standard (STF, 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 picture is complex and fragmented; however, the authors have found little evidence of industry wide initiatives that support the ‘People-centric’ focus required to successfully deliver ‘change’ on a scale that is unprecedented.

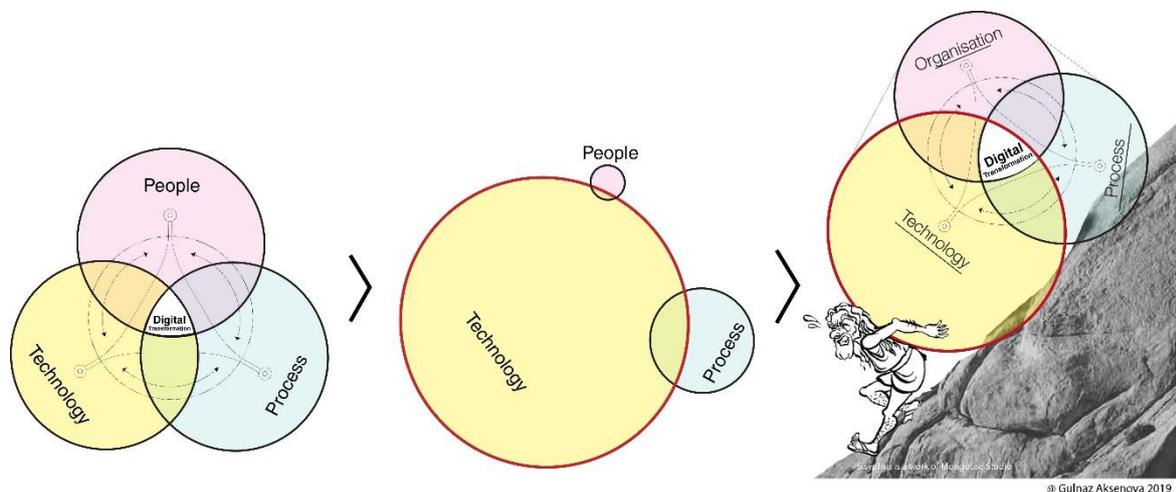


Figure 1. Relationship between People, Process and Technology and the perceived imbalance in the focus of initiatives (Adapted from Aksenova, 2018)

The Digital Built Britain vision is far more-wide ranging than that envisaged for the 2016 UK Government BIM Mandate. It follows that, although BIM Training is an important first step towards the Digital Transformation Journey, success will require an evolved upskilling philosophy.

Following the Grenfell Fire tragedy, the report by Dame Judith Hackett (2018) entitled, “*Building a Safer Future*” 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. The following conclusions from the report are relevant to PUN:

- A competence problem exists resulting from the lack of effective strategies for competence definition, development, management and, importantly, assurance.
- There is a lack of clear and consistent information management strategies, meaning that finding the right information to make timely decisions is often impossible. For this, 'Building a Safer Future' used the term the 'Golden Thread' of information.

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.

A Steering Group on Competences for Building a Safer Future has been set up by the Construction Industry Council (CIC, 2018) and aims to complete their proposals for April 2019 that 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 to the statement 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;
- 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 competence 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 to as much a manifestation of the failures relating to the mediation of competence supply and demand as the failures relating to the flow of purpose driven information.

Over the course of the network, two primary questions emerged:

- **What is required to facilitate the emergence of an ecosystem based on the effective mediation of competence supply and demand within the construction sector and wider built environment?**
- **How do we support the competence development, management and assurance of individuals and teams throughout their career in the built environment?**

These are broad topics. **This report suggests a number of questions and recommendations relevant to PUN that need further attention at the next stage of the CDBB initiative.** A successful response will require different combinations of leadership from industry and government, fundamental research, and pilot projects to rigorously measure impact and effectiveness.

2. The Ecosystem of the Digital Built Britain

The key challenge of Digital Built Britain 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 stakeholders that comprise the ecosystem of the Digital Built Environment, for example:

- 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 the delivering the project at any stage of the asset lifecycle, 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 assuring the competence of practitioners;
- Those responsible for the regulatory framework and the development of standards;
- 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 Digital Built Environment 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 Digital Built Environment Ecosystem, it became apparent during the PUN workshops that 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 following classification of initiatives was proposed:

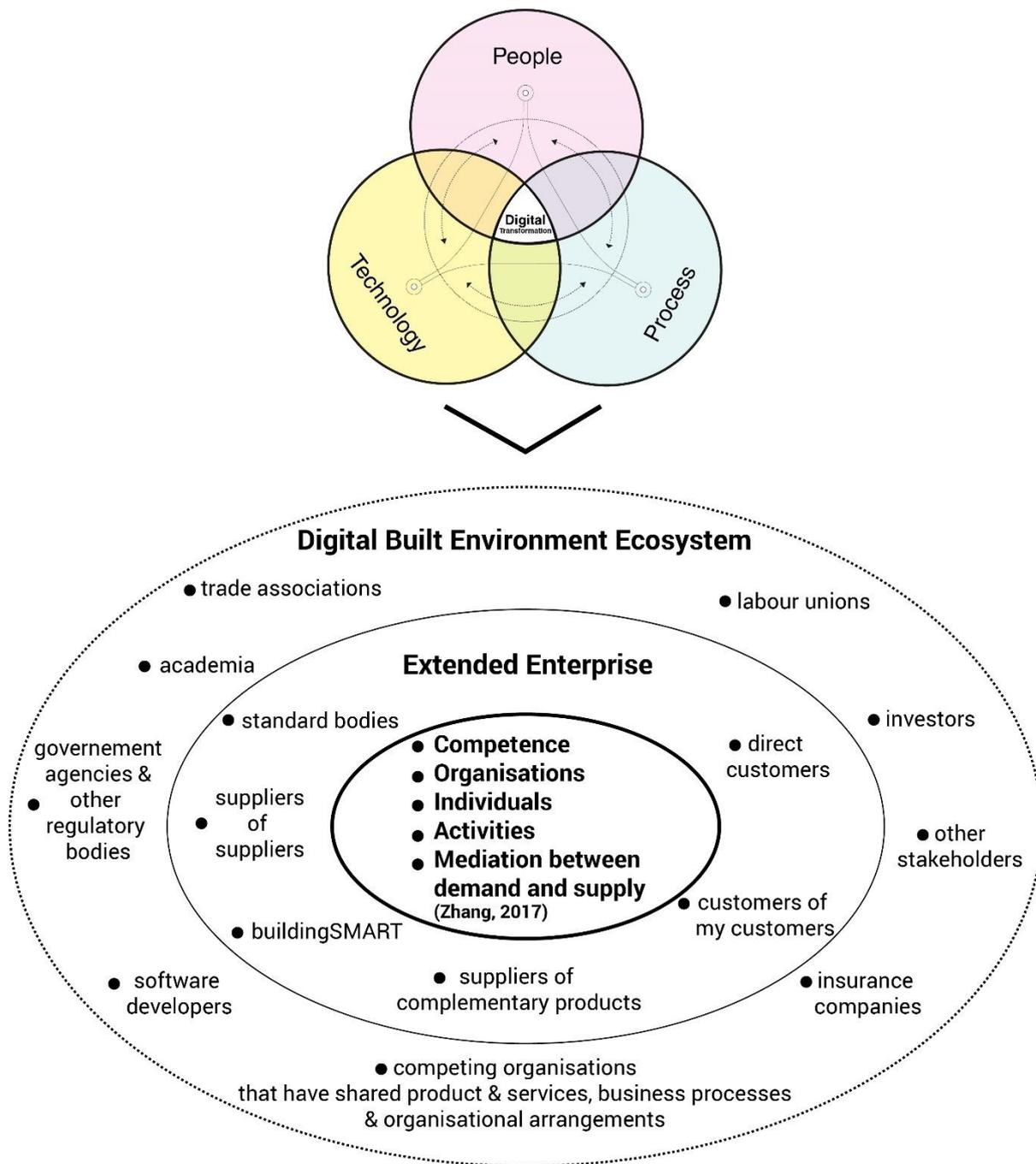


Figure 2. Proposed alternative to People: Process: Technology (Figure on ecosystem is adapted from Moore (1997) and the concepts on an ecosystem of competency mediation between demand and supply are adapted from Zhao (2017))

Furthermore, the PUN categorised the proposed initiatives as having ‘Research’ focus (TRL 1 → 5) teams or an ‘Implementation’ focus (TRL 6→9). Although PUN is aware that the next stage of CDBB will have a research focus, we need to ensure that someone, somewhere is looking at the implementation-focused initiatives as success relies on the interdependence of all initiatives across the ecosystem. PUN also concluded that 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.

The Ecosystem of the Digital Built Environment has a critical function as it sets out the norms of interactions between individuals and organisations, and organisations with other organisations; Process and technology are the means by which these interactions take place. A recent study (Aksenova et al., 2018) 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 that 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 Ecosystem. As a lesson learnt, the government of Finland established a new programme in 2016, named Kira-Digi. Kira-Digi has brought about a new experimental 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 ecosystem, while *“The €16M programme’s vision is to develop an open, interoperable information management ecosystem for the built environment”* (Törrönen, 2017).

Clarysse et al. (2014) analysed a knowledge ecosystem creation 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. Different types of ecosystem require specifically tailored policies. 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 ecosystem projects 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-based management across sectors, disciplines, professions, etc., matters more than targeting productivity improvement through rapidly changing technologies.

There is a significant risk that, if the ecosystem of the Digital Built Environment does not re-design its 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-based 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).

The relationships between the professional institutions, universities, government, the industry and other stakeholders of the competence management ecosystem are, therefore, critical if a competent workforce is to mitigate risks. For example, the conclusion from the PUN workshops suggested that funders and insurers could be critical partners to ensure that real change happens within the Digital Built Environment Ecosystem, particularly away from projects covered by the 2016 UK Government BIM mandate.

In addition, the PUN workshops reached a consensus that 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.

Initiatives proposed by PUN are referenced throughout the report and covered in detail in Appendix 7.

3. Competence 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. **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 competence-based management. The two key stakeholders in competency mediation are those who demand competence (i.e. asset owners and employers) and those who supply competences (workers). They are the primary stakeholders. The secondary stakeholders (government, professional bodies, trade associations, etc.) are mediators between the supply demand relationships. 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. There is an increased UK Government focus on meaningful (good) work following the Taylor Review (Taylor Review, 2017). The innovation needed is how to make the value and meaning of work and competence explicit to enable this. Currently, the proxy for competency demand is occupation and role. The proxy for competency supply is qualifications. 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 and attitude at work (Zhao, 2015).

Furthermore, competence is only truly gained through its repeated application at work. This is critical as it underlies why the solution to the productivity problems of the industry does not lie in 'training' alone.

- 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-qualification, 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 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’.

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 have 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:

- Inconsistent exchanges of information at the project inception e.g. requirement capture, briefing, proposals and pricing;
- **Inconsistent definition of activities** leading to inconsistent information requirements and programming;
- Inconsistent, incomplete, ambiguous and ultimately unverifiable information deliverables leading to subjective decisions across the project stakeholders and lifecycle;
- Inconsistent and non-transparent cost data leading to inconsistent pricing;
- **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;**
- 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 infrastructure to facilitate the mediation of competence 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 of the asset during the delivery, in-use and end-of-use phases. **If we just digitise existing traditional (document-centric) processes, do we risk constraining our 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 are within the remit of PUN. We recommend that the other points are acknowledged and covered by other CDBB or wider industry initiatives.

3.1. Inertia in the paradigms of the Construction Industry and the wider Built Environment

There is considerable history and inertia regarding the professions 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 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). ‘Occupations’ and ‘professions’ have, in turn, become a proxy for competence demand (CEDEFOP, 2013); for example, 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 technological innovation. Theoretically, any organisation can participate in a design or construction project in any location (Langford & Male, 2008) and technology 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 competence supply and demand, then it follows that the proxies we use for competence supply and demand are also neither granular nor dynamic enough for the changing world of work.

The OECD (2017b) identified in the UK:

- A 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;
- A low demand for higher order competences;
- The increasing polarisation between high-end skills and low-end skills, which increases mobility challenges.

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

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 skills¹’ 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 (IPPR, 2017; Schouten, 2016; 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?**

Furthermore, technological 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. As workforce transformations accelerate, the window of opportunity for the proactive management of

¹ Note: Skill is the functional ability the person or agent has to perform activities and actions (Zhao, 2015). Skill is a dimension of competence but is often used to convey a broader meaning.

this change is closing fast. If the transition towards digitalisation is managed poorly, it poses the risk of a widening skills 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). A greater shift from the inward looking goals of individual organisations to an innovation ecosystem with a collaborative approach is needed. The traditional structures of ‘roles’ and ‘occupations’ could therefore act to constrain the skill/competence composition of the employer, their contribution to job growth and ultimately productivity.

To address these challenges two further key questions need to be addressed:

- **What does upskilling look like through the lens of competence?**
- **What is the infrastructure required to support the mediation of competence supply and demand?**

3.2. The link between competence and activity at work

All individuals have competency, which is a profile of the many different dimensions of competence that an individual has in terms of their knowledge, skills, experience and behaviours related to the work activities they have done, can do, are qualified to do, etc. This profile, in part, signifies an individual’s effectiveness in the day-to-day activities required as part of their role or job or task². 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.

Activities are the fundamental building blocks of work³ When we look at built environment projects, which involve multiple organisations collaborating and contracting with each other, we also note that, 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

Projects are a collection of activities

We have recognised the potential that consistent structuring of information could have for productivity. The Industry Foundation Class (IFC) is a non-proprietary schema for defining how information can be structured to describe the built environment. However, the built environment has no such schema to define how activities can be consistently semantically linked. Of the frameworks that currently exists (STF, 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;
- Some are internationally based and have not been tested in the UK context;
- Some 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

² Note: this is **not** how effective they are at their role or job or task, as other evidence sources are required to provide assurance of effective performance.

³ Note: For the purpose of this report an ‘activity’ has a definable and intentional result.

occupational roles, the scope for Digital Built Britain is significantly more comprehensive than simply BIM moving towards a digital transformation within Digital Built Environment ecosystem.

The challenge lies within the demand side; this needs to become a more responsible and intelligent actor in this mediation. As IPPR (2017) noted, *“Demand for skills 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 have capabilities to lead and define the value they need. Therefore clients themselves require certain competences in order 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 Hackett Report (2018) 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”*. This highlights the need for collaborative competency management so the interactions of work activities, actors (worker), actions and outcomes can be understood more explicitly in competency and information management terms.

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, 2028)*

This is compounded by the lack of knowledge on the impact of a competence gap, shortages, and mismatches on productivity, labour mobility and diversity (i.e. just 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 (see Figure 4) by understanding competence 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.

Activity Semantics (Zhao, 2012) is an emerging technique that could solve this challenge, but that requires testing, and perhaps adapting, for Digital Built Environment applications. These semantic links would underpin a **Competency Framework**, which in turn would underpin any **Competency Definition**.

UKBIMAlliance (Simpson & Carlton, 2019) proposed that the requirements for a Competency Framework would need to be extensible, machine-readable and definable along the same axis as competence (i.e. knowledge, skills, experience, attitudes, behaviours, etc.).

A fundamental aspect of Competency Demand is Competency Definition

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 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?'*

And then to 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 competence as the computational unit (Zhao, 2012).

If we can consistently define the competency profile required for an activity then we can effectively match this against the competency profile of an individual or team. This can be scaled up the aggregation of activities required for a role, team, workpackage, project, organisation and even across the whole industry/sector. This 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 competences, qualifications or field of study (discipline). The mismatch can be classed as over-skilled/qualified, or under-skilled/qualified, for example, or due to skills decay.

The difference between the competence required (for an activity) and the competence 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 not quickly applied and reinforced by experience, the knowledge/skills are lost.

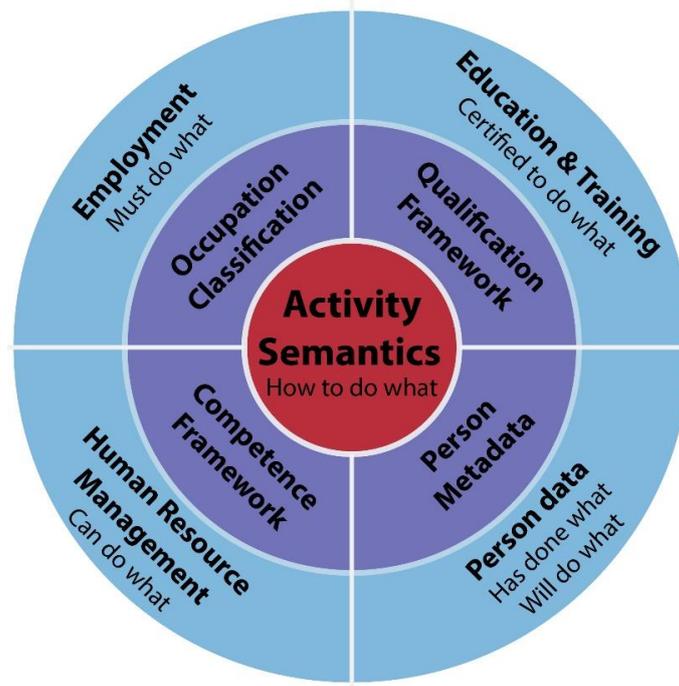


Figure 3. Adapted from Core of Competency [© Interlates, see Zhao, 2017a]

**Productivity of people comes through the successful mediation of
Competency Supply and Demand (Zhao, 2017)**

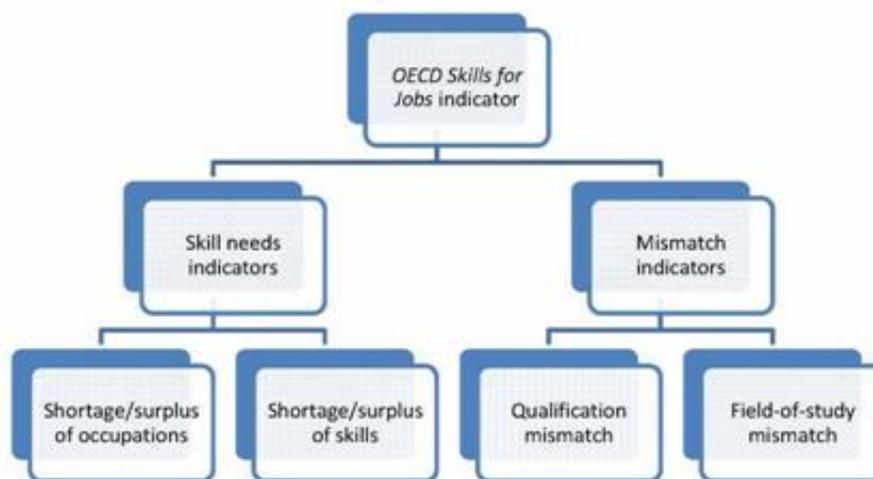


Figure 4. The structure and components of the OECD Skills for jobs indicators

The Competency Profile of the individual is not static; certain competences can grow and other diminish through a lack of use. This is not immediately obvious to either the employer or the individual. An infrastructure that allows the individual to transact on the basis of their competence 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 an 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 through education and/or training and/or experience.

Upskilling is the conscious migration of one competency profile to another (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. 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. Competency management can potentially target this issue such these efforts are coordinated across the ecosystem. A universal matrix of competences across ecosystem stakeholders would promote the knowledge of what competences are required in the labour market.

3.3 Competency as currency in the labour market

People are central to productivity in the competency of the current and future workforce. If individuals and employers have the infrastructure and a digitally enabled ecosystem within which to transact on the basis of competence, then competence would become a currency within the labour market. Competences 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 competency 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/employers have no infrastructure with which to transact in the marketplace or to manage their career portfolio data (Zhao, 2014), and neither is the individual a stakeholder in the ecosystem. Competent people are a source of innovation and productivity and therefore they are a foundational bid in the domain of DBB. However, competent people are usually a lost or not recognised asset for organisations and demand. Competency-based management must therefore be delivered with a people-centric approach (Zhao, 2018).

The key is value and the meaning of work where attributes of competence in relation to why, how and what become critical to meaningful work, engagement and self-actualisation, and to improving productivity and reducing risks, as noted by the Skills Review Group (2018). The CPD, professional, trade and education bodies are 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 Competency 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 approach to competency management across the ecosystem of the digital built environment. A new Digital Built Environment Ecosystem underpinned by the mediation between competence supply and demand would enable a new paradigm to emerge, which would transform the productivity of Built Environment Professionals and Organisations of Digital Built Britain.

3.4 The infrastructure required to facilitate a new digitally enabled ecosystem underpinned by the mediation between competence supply and demand

**The activity, the information required/delivered by the activity and the competence to carry out the activity are all intrinsically linked
(Simpson & Carlton, 2019)**

A new digitally-enabled Digital Built Environment Ecosystem underpinned by the mediation between competence supply and demand would require a new infrastructure (and underpinning research to):

- A **Competence Framework** to enable consistency and a **definition of Competency** for a particular activity;
- 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 or ecosystem where the need, existence, extent, currency, validity, and

meaning of competency can be understood and securely shared in a transparent and auditable manner;

- 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.

Currently the infrastructure to enable this does not exist. However, once the infrastructure exists then **Competency Analytics** (Zhao, 2018) is possible; Competency analytics is a set of technologies and methodologies for competency management. It is 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.

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, 2015). 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.

The infrastructure can provide the opportunities to increase the transparency of competency data on individuals and organisations; currently available data is mostly not 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. Currently, demand forecasting in the UK is based only on occupational classification. An effective infrastructure across the ecosystem can enable workers to transact effectively in the labour market based on their competences, and competences can act as a true currency for work, professional development, training, credentials, careers, labour planning, certification, assurance, etc.

4. Lifelong Learning and Competency Supply & Demand

Evidence shows that the environment 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 in the PUN Workshops.

Workers who better use their skills are more likely to have greater job satisfaction, earn better wages 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 an ecosystem that empowers competent individuals, through the Conscious Competency Evolution, to be responsible for managing their own career. The Conscious Competency Evolution relies on robust lifelong learning opportunities and infrastructure. This is compatible 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.

Lifelong learning is typically split into three phases:

- 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.
- 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
- Continued Professional Development (CPD) and re-qualification

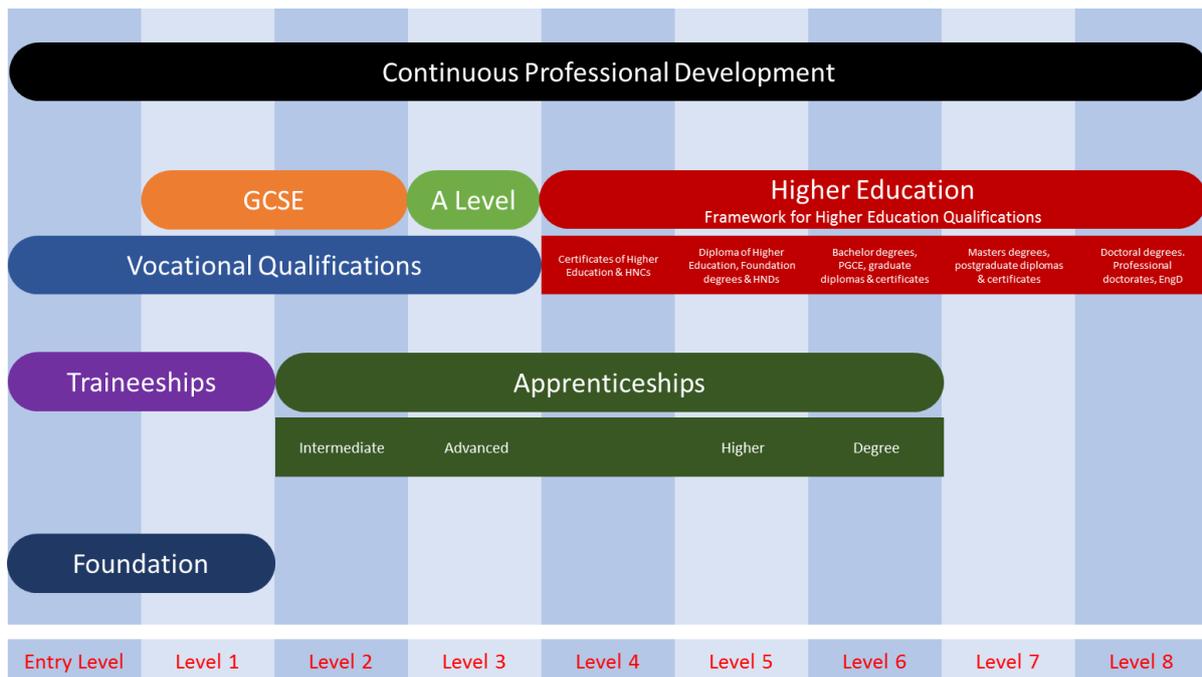


Figure 5. Phases of lifelong learning

It is not the scope of PUN to address Pre-18 education; however, it was recognised that 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. Key areas of action are:

- Improved career advice;
- Initiatives, e.g. DEC⁴;
- Greater involvement of construction professions with schools.

⁴ <https://designengineerconstruct.com/what-is-dec/>

The conclusion of PUN was that, when examined through the lens of competency, both the Post-18 and CPD aspects of lifelong learning are out-of-date and not fit-for-purpose. The education system is focused on producing a workforce for the previous industrial revolution, while we are about to embark on the next.

4.1 Lifelong learning and HE

It was recognised that an undergraduate degree is a good vehicle to provide a dense package of pre-requisite knowledge prior to embarking on a career. The Royal Academy of Engineering (2007) stated that, whilst 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 report stated that it had become more acute in recent years and was identified as one of the skill shortages impacting business growth. A concern was raised at the PUN workshops as to whether HEIs were able to keep up with the industry's fast pace of change. It was reported that some employees felt they were unable to recruit graduates with the relevant digital competences.

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. One suggestion from the workshop was to investigate the system of medical education to see if lessons can be learnt. For example, trainee doctors undertake a degree in general medicine prior to specialising in a particular branch.

One suggestion was that Built Environment courses should be split into a 'generalist' degree followed by a 'specialist' masters level. There is much merit in this; however, it is also recognised that the specialist colleges in medicine are just as impacted by a silo mentality as the construction industry. 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 institutions. Furthermore, it is accepted that HEIs have limited scope for innovation if their courses are to be accredited. Several academics at the workshop stated that, 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 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; historically, many HEI's recruit research professionals to ensure they meet the requirements for the Research Excellence Framework (REF). This is further reinforced through promotion routes that favour those with success in winning grants and publications. 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 practise. As we move towards a more digitally enabled future, the 'human-centric' competencies involving multi-disciplinary teamworking, creativity, innovation and design will become more important as the traditional technical aspects will be taken over by Machine Learning and AI. The pressures 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. 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).

The BIM Learning Outcome Framework (BSi, 2019) aims to facilitate consistency in the development and delivery of digitally enabled built environment education. Similarly, the UK BIM Academic Forum (BAF) have 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). Further work is continuing to break down and establish the potential learning outcome requirements at each level of HE (i.e. 4-7). However, adopting such 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). This is similarly evident in industry where the understanding, acceptance and importance of digital transformation amongst Higher Education 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 (BIM2050, 2014). Moreover, this is still considerably short of an ecosystem that would facilitate 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 have as great a need of a conscious competency evolution as industrialists.

Amongst the case studies (RAEng 2010) that demonstrate an exemplary engagement between industry and universities, there is a lack of data to show whether this is a consistent story or whether, for some, interactions only occur through occasional meetings with their Industrial Liaison/Advisory Committees.

The PUN workshops debated whether universities should play a more significant role in the lifelong learning journey beyond the provision of degree programmes. This is not to say that HEI's 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 workforce. While digital construction is becoming more widespread across various levels of education, in the main, the approach tends 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 (Underwood, 2014; BAF, 2015).

The introduction of the Apprentice Degree is a welcome concept to bridge the gap between industry and academia. It remains to be seen as to whether the Apprentice Degree delivers the potential for a true collaboration between industry and academia in the upskilling of the workforce, or simply provides a day-release course under another name.

4.2 Lifelong Learning, CPD and Professional Institutions

Professional Institutions have evolved in a manner that reinforces the siloed 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).

The Professional 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.

The Professional Institutions also influence the provision of Continued Professional Development (CPD). CPD is the means by which Professional Institutions assure that their members remain competent, as beyond the Initial Professional Review, there are no further checks. However, the recent ICE Skills Report (ICE, 2018) states that the current CPD model is not fit for assurance. Furthermore, *“civil engineers who fail to keep abreast of changes affecting their areas of activity are simply unfit to practise”*.

The challenges that the ICE 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
- There is a lack of consistency and transparency that would limit the effectiveness of mandatory auditing.

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 the member’s career.

Professional 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 siloed nature appears too entrenched to provide any industry wide leadership in this area. The multiplicity of 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 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 institutional level (Morrell, 2015), and the characteristics of their business models are contradictory to what the Industry 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 Hackett Implementation Plan, that engineering 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 infrastructure or ecosystem to enable this.

4.3 Lifelong Learning and the Providers of CPD

The provision of CPD is fragmented and disjointed. Furthermore, there is no consistent framework, which in turn means:

- It is impossible for individuals to compare one provider’s course against another when they have identified specific competence development requirements.
- It is impossible 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 and ecosystem to facilitate comparison does not exist, providers cannot be blamed for their attempts to respond to market forces.

The lack of infrastructure and ecosystem 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 ICE has undertaken some foundational work in this area.

It is well documented that, unless an individual applies the skills and knowledge they gain from a training course 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.

Moreover, it is unclear what real effect or change will be brought about by the mandatory CPD auditing and reporting required from Jan 2019.

4.4 Unlearning: Selecting an alternative mental model or paradigm to enable digital transformation

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, whereby 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. The misconception is that unlearning is about forgetting; 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. When we unlearn, we step outside the mental model in order to choose a different model. Therefore, in a time of (digital) transformative change, we need to be conscious of our mental models and ambidextrous in our thinking (HBR, 2016).

4.5 Pedagogy

This network started with the goal of investigating the research questions and initiatives required in the pedagogy as well as in upskilling. However, it quickly became apparent that the logical order for the industry would be to:

1. Define what upskilling needs to mean in terms of competence, and in particular the phrase, conscious competence evolution;
2. Define the ecosystem to support a competence-based approach to upskilling and enable the conscious competence evolution;
3. Define the pedagogy that best suits the required upskilling.

5. Research Questions

The research conducted in this project has determined fifteen questions to guide further research. If these questions are addressed in future research activities, then the network is confident that the pedagogical and upskilling aspects of Digital Built Britain can be realised.

Table 1 shows a summary of the key research questions; it has been structured to demonstrate:

- The level of potential impact from answering that question;
- The urgency of the research needed;
- The current maturity level of the research (i.e. determining the research on what already exists);
- Who should lead the research?

These results have been determined through consultation with the network.

Table 1. A summary of the research questions and their significance in moving forward

Q. No.	IMPACT	URGENCY	MATURITY	LEAD BY
1	HIGH	IMMEDIATE	MEDIUM	JOINT
2	HIGH	IMMEDIATE	MEDIUM	JOINT
4	HIGH	IMMEDIATE	MEDIUM	JOINT
5	HIGH	IMMEDIATE	NOVEL	JOINT
7	HIGH	IMMEDIATE	NOVEL	JOINT
10	HIGH	IMMEDIATE	MEDIUM	JOINT
11	HIGH	IMMEDIATE	NOVEL	JOINT
3	HIGH	MEDIUM	MEDIUM	JOINT
6	MEDIUM	MEDIUM	MEDIUM	JOINT
12	HIGH	MEDIUM	NOVEL	JOINT
13	MEDIUM	MEDIUM	NOVEL	ACADEMIA
14	HIGH	MEDIUM	NOVEL	ACADEMIA
15	HIGH	MEDIUM	NOVEL	JOINT
8	HIGH	LOW	NOVEL	JOINT
9	LOW	LOW	MEDIUM	JOINT

5.1 What are the immediate research questions to consider?

Table 1 illustrates that there are seven questions labelled 'IMMEDIATE' in terms of urgency; these need to be addressed in the first instance. The network has determined that, in answering these research questions, there is the potential for a 'HIGH' impact on the industry. Of these seven questions, there is a medium level of 'MATURITY' in current, existing research.

The network results have shown that the key questions that need IMMEDIATE research are:

- Question 5 How do we design/manage/implement a 'collaborative competence management' approach that enables/facilitates competence as a currency in the labour market?
- Question 7 How does curriculum development need to adapt to align to a 'collaborative competence management' approach?
- Question 11 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?

The network deemed Question 8 to be of low urgency; this is because the network was generally industry biased. However, having considered the nature of the question it has been deemed to be very important in the development of the education side of research. The question is:

- Question 8 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?

The full set of research questions are presented in the Appendices. Under **Question 5** the following subset of questions are needed to answer the wider question 5:

- Question 1 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?
- Question 2 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?
- Question 4 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?
- Question 10 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.

5.2 What are the medium-term research questions to consider?

If the research highlighted in section 5.1 can be achieved, then the next phase of research can be considered in the medium term. The medium term is considered to be three to five years from this year of the report. If further research is to be undertaken, the following research questions need to be addressed:

- Question 3 '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'?

- Question 6 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?
- Question 12 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?
- Question 13 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?
- Question 14 How does the conscious competence evolution lead to agility and resilience in the workforce?
- Question 15 How does an individual competence development approach allow individuals displaced by the new industrial revolution to thrive and contribute to society?

Questions 5 and 7 are addressed by some existing documented research, and some of this has been identified in this network. Questions 3,6,12,13,7 & 15 are deemed to be novel in that there is no significant current research in these areas.

5.3 What is the long-term question to consider?

In the context of this study, long-term is deemed to be research that should be undertaken in five to ten years from now. The key question to consider here is:

- Question 9 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?

The final observation from the results of the research questions is to ascertain whether any further research activities in this area need 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. The research discussed here is necessary to achieve Digital Built Britain.

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7. Appendices

Glossary

The research has highlighted an important need to define the terminology before proceeding further with the propositions.

No potential distinction of competence(s) and competency(cies) is made; the latter is the collective noun of the former, whilst competence, competences and competency⁵ are consistently adopted.

An activity is a major unit of work to be completed in achieving the objectives of a process. An activity has precise start and end dates, incorporates a set of tasks to be completed, consumes resources, and results in work products. Understanding 'activity' is fundamental to improving productivity. Activities are often common between projects and country even though they may be carried out by different 'roles' and 'ecosystem stakeholders'.

Body of Knowledge (BOK or BoK) is the complete set of concepts, terms and activities that make up a professional domain, as defined by the relevant learned society or professional association. [It] is "a set of knowledge within a profession or subject area, which is generally agreed as both essential and generally known." (Gary R. Oliver)

"Competence is the ability of an individual to do a job properly and is held to be a combination of knowledge, skills and ability. 'Knowledge' is what you know, while 'skills' and 'ability' are what you are able to do: the difference is that 'skills' can be learned while 'abilities' are innate and unchangeable (at least, in an adult)" (ICE, 2018). It is the ability to perform a professional activity with required knowledge, skills, and attitudes (Zhao, 2012). Furthermore, it is a competence profile; a set of competences associated with a person, team, task, role, project, profession, service, process, practices, courses, publications, and policy (Zhao, 2012).

Competence (a working definition (Zhao, 2012)): is the ability demonstrated in an activity at work. It has multiple aspects, and is expressed in terms, such as abilities, skills, experience, expertise, knowledge, education, qualification, behaviour, aptitude, values, and attitudes. Its denotation, classification and quantification are context sensitive, stakeholder-dependent and application specific.

Competency is 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 is 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).

Core competence defines a firm's fundamental business. Value can be enhanced through a combination with the appropriate complementary assets. The degree to which a core competence is distinctive depends on how well endowed the firm is relative to its competitors, and on how difficult

⁵ "There is such confusion and debate about the concept of competence that it is impossible to identify or impute a coherent theory or to arrive at a definition capable of accommodating and reconciling all the different ways the term is used" Zhao, G. (2012). Competence semantics: engineering and application. *International Journal of Knowledge and Learning*, 8, 112-133.

it is for competitors to replicate its competencies. Core competence is the communication, involvement and deep commitment to work across organisational boundaries. It involves many levels of function and people (Prahalad & Hamel, 1990).

Capability is defined as 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).

Distinctive competence is a difficult-to-replicate or difficult-to-imitate competence/capability (Selznick, 1957).

Dynamic capability is *“the firm’s ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments”* (Teece et al., 1997). This is why dynamic capabilities are conceived as routines/activities/competencies embedded in firms (Eisenhardt & Martin, 2000).

Ecosystem is defined by *“the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize”* (Adner, 2017).

Job is an instantiation or extension of a role(s) for a specific context. A job can have ‘n’ roles but, increasingly, organisations are moving away from planning based on roles to activity-based planning.

Organisational routines/competences are firm-specific assets assembled to enable distinctive activities to be performed. These activities constitute organisational routines and processes. Examples include quality, miniaturisation and system integration. Such competences are typically viable across multiple product lines and may extend outside the firm to embrace alliance partners.

Profession is *“An occupation in which an individual uses an intellectual skill based on an established body of knowledge (BoK) and practice to provide a specialised service in a defined area, exercising independent judgement in accordance with a code of ethics and in the public interest.”* (Professions Together, 2015)

Pedagogy is defined by the Oxford Dictionary (2018) as *“The method and practice of teaching, especially as an academic subject or theoretical concept”*.

Resources are the tangible and intangible assets of a firm, which can be drawn upon by the firm when required to achieve its objective(s). Resources are firm-specific assets that are difficult if not impossible to imitate (Teece, 2007).

Reskilling is the process of learning new skills in order to do a different job, or of training people to do a different job⁶. This enables the transition of workers from adjacent sectors, professions or disciplines that require reskilling. Reskilling is the evolution of one competency profile to another.

Role is an aggregation of activities that a person carries out as part of their day-to-day work. Roles are often company specific and may have different job titles for the same role or the same job title for different roles. Roles can be organised by a profession or activity, i.e. this role belongs to that profession, or this activity requires the performance of these roles; this is not a one to one relationship.

Routines relate to coordination and are firm-specific in nature (Fujimoto & Clark, 1991).

Technological capabilities consist of both dynamic and operational capabilities that form a collection of routines/activities in order to execute and coordinate the variety of tasks/activities required to manage technology.

⁶ <https://dictionary.cambridge.org/dictionary/english/reskilling>

Upskilling is the process of learning new skills or of teaching workers new skills⁷

Work is any activity performed by persons of any sex and age to produce goods or to provide services for use by others or for their own use. This includes own-use production work, employment, unpaid trainee work, volunteer work or other forms of work (ICLS, 2013).

⁷ <https://dictionary.cambridge.org/dictionary/english/upskilling>

Research Questions

Research questions primarily focused on ‘Organisations’:

O.1	How do the Professional Institutions and Trade Organisations (PI&TO) need to evolve to retain (or reclaim) their relevance in an increasingly multi-disciplinary world where the boundaries of role and profession are blurred through increasing Digitalisation? – COLLABORATION CHALLENGE
TRL	7-9: Industry Led
Timeframe	3+ yrs
Prerequisites	CIS required to provide a framework within which the PI&TO can
Notes	Independent leadership is required as the professional institutions are not known for their ability to work together. Suggestion would be someone from the Construction Leadership Council (CLC) or a respected independent.
O.1.1	What should the PI&TO approach be to competence development and assurance beyond chartership or initial professional review given that the overwhelming evidence is that CPD in current form is not fit-for-purpose?
TRL	4-6: InnovateUK
Timeframe	18 mths
Prerequisites	
Notes	

Research questions primarily focused on ‘Ecosystem’

E.1	How should the post-18 education system (including HEI, vocational training and CPD) be reformed to be compatible with the twin requirements of the wider Built Environment ecosystem i.e. based on the principles of competence development and to support/enable life-long learning?
TRL	
Timeframe	
Prerequisites	
Notes	
E.1.1	How should pre-18 education system prepare future professionals of the Build Environment?
TRL	
Timeframe	
Prerequisites	
Notes	
E.2	In terms of the procurement processes, how, in particular, is competence supply and demand defined and managed as well as assessed and allocated?
TRL	
Timeframe	
Prerequisites	
Notes	
E.3	In terms of the funding process, how, in particular, could risk be managed in relation to the confidence in the competence of those delivering the project?
TRL	
Timeframe	
Prerequisites	
Notes	
E.4	In terms of the innovation process, how, in particular, can we support, nurture and grow the role of innovation with the Built Environment?
TRL	
Timeframe	
Prerequisites	
Notes	

Feedback on Proposed Questions (Data Analysis)

1												
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?												
Relevant Questions		A	B	C	D	E	F	G	H	I	J	Total No
Is this a valid research question for CDBB and PUN	Yes			✓	✓	✓	✓	✓				5
	No		✓									1
Impact	High			✓	✓	✓		✓				4
	Medium						✓					1
	Low		✓									1
Urgency	Immediate			✓		✓		✓				3
	Medium						✓					1
	Low		✓									1
Maturity	Mature		✓									1
	Medium					✓	✓	✓				3
	Novel			✓	✓							2
Research → Implementation	Mainly research		✓	✓	✓							3
	Balance of Research & Implementation						✓	✓				2
	Mainly Implementation					✓						1
Is a key component (>60%) of this work an assessment of current practice?	Yes		✓		✓		✓					3
	No			✓		✓		✓				3
Collaboration with industry?	Led by industry											
	50:50			✓	✓	✓	✓	✓				5
	Led by research		✓									1
Comments / Rationale		<p>B: There may not be a lot of research on the construction trade concept of competency, but competency as a concept is pretty universal. It seems this would do well to be somewhat combined with 4?</p> <p>C: This is a fundamental question to be answered to achieve the PUN objectives and to develop the theoretical framework</p>										

		progress with the study. Assessment of current practices only limit the identification of competencies required to deal with the new innovations and developments.	
Are you aware of anyone leading this area?		<p>B: Depends which competence model you're looking at, see the newly release CIPD Professional Map!</p> <p>E: Elizabeth Kavanagh, Behaviours4Collaboration – someone who actually understand this in the context of construction</p> <p>Alison Watson, DEC in Schools – passion for improving the industry</p> <p>G: Dr Gang Zhao & myself</p> <p>Oil & Gas Sector</p> <p>University of Plymouth did short research paper I contributed to as part of Innovate UK Skills Planner project</p>	

2

Who are the stakeholders that any built environment sector work on 'competence management' and 'competence development' will have to engage with. How are they interconnected with other stakeholders? What is their sphere of influence?

Relevant Questions											Total No
Is this a valid research question for CDBB and PUN	Yes	✓		✓	✓	✓	✓	✓			5
	No		✓				✓				2
Impact	High	✓		✓	✓	✓	✓	✓			6
	Medium										
	Low		✓								1
Urgency	Immediate			✓		✓	✓	✓			4
	Medium	✓	✓		✓						3
	Low										
Maturity	Mature	✓									1
	Medium				✓	✓	✓	✓			4
	Novel		✓								1
Research → Implementation	Mainly research		✓		✓						2
	Balance of Research & Implementation			✓		✓	✓	✓			4

	Implementation											
	Mainly Implementation											
Is a key component (>60%) of this work an assessment of current practice?	Yes		✓									1
	No			✓	✓			✓	✓			4
Collaboration with industry?	Led by industry					✓						1
	50:50		✓	✓					✓			3
	Led by research				✓		✓					2
Comments / Rationale		<p>B: Bit high level 'what is upskilling?' Really the question is 'what are the required competences for the built environment in the next 5, 10, 20 years to deliver DBB, etc, and what is the gap between current skills and future expected skills?' I'd say competence mapping is a good start before we start talking about upskilling, as the map feeds the actions to be taken.</p> <p>C: Identification of a set of skills required for BE professionals is important before looking about upskilling. Upskilling requires an assessment of current practices and then comparing with what is required. I do not think upskilling is appropriate as this refers more to the development of an existing workforce and hence it may not be inclusive.</p>										
Are you aware of anyone leading this area?												

4

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. How can we define/develop a flexible/extensible ontology that describes the activities of the built environment?

Relevant Questions												Total No
Is this a valid research question for CDBB and PUN	Yes	✓	✓	✓	✓			✓				5
	No					✓	✓					2

Impact	High	✓	✓	✓	✓			✓				5
	Medium					✓						1
	Low						✓					1
Urgency	Immediate		✓	✓	✓			✓				4
	Medium					✓						1
	Low						✓					1
Maturity	Mature							✓				1
	Medium	✓		✓	✓	✓		✓				5
	Novel		✓					✓				2
Research → Implementation	Mainly research			✓	✓			✓				3
	Balance of Research & Implementation		✓			✓		✓				3
	Mainly Implementation	✓										1
Is a key component (>60%) of this work an assessment of current practice?	Yes	✓	✓		✓	✓						4
	No			✓				✓	✓			3
Collaboration with industry?	Led by industry			✓	✓							2
	50:50		✓			✓		✓				3
	Led by research			✓				✓				2
Comments / Rationale		<p>A: New philosophy, less role dependant</p> <p>B: This is a critical piece of the puzzle, as very few people understand the activities, and what they actually mean. Research should be highly focused on this area. Running some pilot research around the impacts of specific activities could be highly beneficial.</p> <p>C: Activities are linked with roles, not sure the statement is accurate about the consensus about the definition of competence.</p> <p>F: My feeling is that the industry is already quite well served by definitions of activity-based competence, through the professional bodies.</p>										
Are you aware of anyone leading this area?		E: Arup Competency Framework, PAS 91										

5

How do we design/manage/implement a collaborative competence management approach that enables/facilitates competence as the currency in the labour market?

Relevant Questions											Total No	
Is this a valid research question for CDBB and PUN	Yes		✓	✓	✓	✓	✓	✓				6
	No											
Impact	High		✓	✓	✓			✓	✓			5
	Medium					✓						1
	Low											
Urgency	Immediate		✓	✓				✓	✓			4
	Medium				✓	✓						2
	Low											
Maturity	Mature											
	Medium					✓						1
	Novel		✓	✓	✓			✓	✓			5
Research → Implementation	Mainly research			✓					✓			2
	Balance of Research & Implementation		✓		✓	✓	✓					4
	Mainly Implementation			✓								1
Is a key component (>60%) of this work an assessment of current practice?	Yes		✓	✓		✓	✓	✓				5
	No				✓							1
Collaboration with industry?	Led by industry			✓	✓							2
	50:50		✓			✓	✓	✓				4
	Led by research			✓								1
Comments / Rationale		<p>B: Big question! So much so that I'm not even sure what the research would be? Hence may not be a valid question until rephrased more specifically? If by 'collaborative competence management' you mean, a universal matrix that allows all in the industry to know what competences are required in the labour market, then this is critical.</p>										
Are you aware of anyone leading this area?		<p>G: Dr Gang Zhao, Intelartes and myself. ICE have done some work with us on this Innovate UK Funded project – SkillsPlanner</p>										

		built some capability but too high level to aid useful matching as not competency based	
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6										
The UK suffers from poor data relating to labour force. To address this, what do we need to measure and how to we measure it? And how does this relate to competence management/ competence development?										
Relevant Questions										Total No
Is this a valid research question for CDBB and PUN	Yes	✓		✓	✓	✓		✓		5
	No		✓					✓		2
Impact	High	✓				✓				2
	Medium			✓	✓		✓	✓		4
	Low									
Urgency	Immediate									
	Medium			✓	✓	✓		✓		4
	Low		✓					✓		2
Maturity	Mature									
	Medium	✓			✓	✓	✓	✓		5
	Novel									
Research → Implementation	Mainly research									
	Balance of Research & Implementation			✓	✓	✓		✓		4
	Mainly Implementation	✓						✓		2
Is a key component (>60%) of this work an assessment of current practice?	Yes	✓		✓	✓	✓				4
	No									
Collaboration with industry?	Led by industry				✓		✓			2
	50:50	✓		✓		✓		✓		4
	Led by research									
Comments / Rationale		A: Essential to determine delivery methods. Data on literacy also required. Are we literate? Longevity of service, pattern of work, experience of education-positive/negative B: Seems more like a question that is already better addressed by other								

		research bodies, such as the CIPD or possibly a professional body for recruitment and talent management? The collection of data around the labour force metrics is really valuable, but not particularly related to the built environment in the context of upskilling at this stage. There would need to be preliminary steps, such as defining a skills framework, before this took place?	
Are you aware of anyone leading this area?		A: NBS E: NCCS G: OECD recent Skills report and Skills Index Institute of Employment Research at Warwick University – Standard Activity and Outcome Classification Nesta been doing work but has limitations Players such as Burning Glass (mine Job descriptions) but CITB found poor data for construction sector Taylor Review	

7										
How does curriculum development need to adapt to align to a collaborative competence management approach?										
Relevant Questions										Total No
Is this a valid research question for CDBB and PUN	Yes		✓	✓	✓	✓	✓	✓		6
	No									
Impact	High			✓	✓	✓	✓			4
	Medium		✓					✓		2
	Low							✓		1
Urgency	Immediate			✓	✓	✓	✓			4
	Medium		✓					✓		2
	Low							✓		1
Maturity	Mature									
	Medium		✓		✓					2
	Novel						✓	✓		2
Research →	Mainly research			✓						1

Implementation	Balance of Research & Implementation				✓	✓	✓	✓					4
	Mainly Implementation			✓									1
Is a key component (>60%) of this work an assessment of current practice?	Yes			✓		✓	✓						3
	No				✓			✓					2
Collaboration with industry?	Led by industry												
	50:50			✓		✓		✓					3
	Led by research				✓		✓						2
Comments / Rationale		B: Curriculum development is extremely vague. For whom? This will mean different things to different people. 'Competence framework/mapping/definition' is more important, and then a curriculum follows that. What are the skills in the workforce and how do they relate to the future picture? Everything else stems from that.											
Are you aware of anyone leading this area?		G: Work by IEEE on learning outcome standards and associated ADL research											

8

How does education need to adapt to become demand led and competence based?

(Is 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?)

Relevant Questions													Total No
Is this a valid research question for CDBB and PUN	Yes		✓	✓	✓	✓							4
	No	✓						✓					2
Impact	High			✓	✓	✓							3
	Medium							✓	✓				2
	Low								✓				1
Urgency	Immediate			✓	✓	✓							3
	Medium								✓				1
	Low		✓					✓	✓				3

Maturity	Mature						✓					1
	Medium					✓						1
	Novel				✓			✓				2
Research → Implementation	Mainly research			✓			✓					2
	Balance of Research & Implementation				✓			✓				2
	Mainly Implementation					✓						1
Is a key component (>60%) of this work an assessment of current practice?	Yes			✓		✓	✓	✓				4
	No				✓							1
Collaboration with industry?	Led by industry											
	50:50				✓	✓		✓				3
	Led by research			✓			✓					2
Comments / Rationale		<p>A: Too broad</p> <p>B: Useful question for follow up, but again I see this links to a primary need for the universal mapping of competences in the first place! If you know that, you'll know if the universities/teachers/facilitators are doing their job by standards and well-defined assessment criteria.</p> <p>F: This is already being addressed by the FE and HE sector through various initiatives (including wider access, online and PT delivery). It strikes me as being a rather wider topic area and one that is not really focussed on, or unique to, the challenges of digital built Britain.</p>										
Are you aware of anyone leading this area?		<p>E: To an extent, Network Rail Challenge Statements (see link below).</p>										

9		
How do we enable individuals to thrive in the workplace?		
What are the means to enable competent and honest individuals to distinguish themselves from incompetent and dishonest individuals?		
Relevant Questions		Total No

Is this a valid research question for CDBB and PUN	Yes											
	No			✓	✓	✓	✓	✓				5
Impact	High				✓							1
	Medium					✓						1
	Low			✓								1
Urgency	Immediate											
	Medium					✓						1
	Low			✓								1
Maturity	Mature											
	Medium				✓	✓						2
	Novel											
Research → Implementation	Mainly research			✓								1
	Balance of Research & Implementation				✓							1
	Mainly Implementation			✓		✓						2
Is a key component (>60%) of this work an assessment of current practice?	Yes			✓	✓	✓						3
	No											
Collaboration with industry?	Led by industry				✓							1
	50:50					✓						1
	Led by research			✓								1
Comments / Rationale		<p>C: First part is ok. The second part of the question seems to be a biased and there is no easy way of justifying incompetency and dishonesty.</p> <p>D: I have suggested that this is not a valid research question for PUN. I do believe that this is a valid and important research question but I think it needs to be led by industry</p> <p>F: This could be better focused, with some specific emphasis on Digital Built Britain.</p>										
Are you aware of anyone leading this area?		G: In terms of making meaning explicit, Dr. Gang Zhao										

If productivity is linked to the competences 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. Why is this not happening? And what is required to circumvent the blocks?

Relevant Questions											Total No
Is this a valid research question for CDBB and PUN	Yes		✓	✓	✓	✓	✓	✓			6
	No	✓									1
Impact	High			✓	✓	✓		✓			4
	Medium		✓					✓			2
	Low										
Urgency	Immediate			✓		✓		✓			3
	Medium				✓						1
	Low		✓					✓			2
Maturity	Mature										
	Medium			✓		✓	✓				3
	Novel				✓			✓			2
Research → Implementation	Mainly research		✓	✓							2
	Balance of Research & Implementation				✓	✓	✓				3
	Mainly Implementation										
Is a key component (>60%) of this work an assessment of current practice?	Yes		✓		✓			✓			3
	No					✓					1
Collaboration with industry?	Led by industry										
	50:50		✓		✓	✓	✓				4
	Led by research			✓				✓			2
Comments / Rationale		<p>A: I feel there is evidence of this element; it is more important to focus on the new ways of working rather than re-engineer the old.</p> <p>B: The link between competence, learning and productivity is the holy grail of the learning and development sector. It would be great to have hard data on this.</p> <p>However the reason this hasn't been done extensively to date is the numerous complicating factors that lead to, at best, weak correlations of data and somewhat wishy-washy conclusions. Could be a</p>									

		difficult thing to unpick realistically. F: The topic of productivity has been touched upon many times within the built environment, but usually in relation to other industries (particularly mass market manufacturing). The question could be better focused to look at the potential for digital tools and approaches to lead to increased productivity.	
Are you aware of anyone leading this area?		E: Reallocation of roles on Ordsall Chord project – Mott MacDonald/AECOM and Severfield. Jason Hyde at MottMacDonald.	

11

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?

Relevant Questions												Total No
Is this a valid research question for CDBB and PUN	Yes		✓	✓	✓	✓	✓	✓				6
	No											
Impact	High		✓	✓	✓	✓		✓				5
	Medium											
	Low											
Urgency	Immediate		✓	✓				✓				3
	Medium				✓	✓						2
	Low											
Maturity	Mature											
	Medium					✓		✓				2
	Novel		✓		✓							2
Research → Implementation	Mainly research				✓							1
	Balance of Research & Implementation		✓	✓		✓		✓				4
	Mainly Implementation											
Is a key component (>60%) of this work an assessment of current practice?	Yes			✓								1
	No		✓		✓	✓		✓				4
Collaboration with	Led by industry											

industry?	50:50		✓	✓	✓	✓		✓					5
	Led by research												
Comments / Rationale		<p>B: Good question, I think there are many areas of unanswered questions here. It also touches importantly on the aspect of competency profiling, which is critical. Other issues mentioned, such as the affordability of retraining, and the desirability of the people in the industry to change to this model, are of critical importance.</p> <p>F: I am unsure of the extent to which this is central to the challenges of DBB. Are we referring mainly to existing members of the workforce, who might need to transition to other modes of working?</p>											
Are you aware of anyone leading this area?		<p>G: Dr Gang Zhao</p> <p>A lot of employability portfolio studies in UK and Europe</p>											

12

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?

Relevant Questions												Total No
Is this a valid research question for CDBB and PUN	Yes	✓		✓	✓	✓		✓				5
	No		✓									1
Impact	High	✓		✓	✓			✓				4
	Medium					✓						1
	Low											
Urgency	Immediate	✓		✓								2
	Medium					✓		✓				2
	Low											
Maturity	Mature											
	Medium	✓										1
	Novel			✓	✓	✓		✓				4
Research → Implementation	Mainly research			✓	✓			✓				3
	Balance of Research &					✓						1

	Implementation											
	Mainly Implementation	✓		✓								2
Is a key component (>60%) of this work an assessment of current practice?	Yes	✓						✓				2
	No			✓	✓	✓						3
Collaboration with industry?	Led by industry											
	50:50	✓		✓		✓						3
	Led by research				✓			✓				2
Comments / Rationale		A: First piece of work! B: I don't know what this means										
Are you aware of anyone leading this area?		A: NBS measuring output G: Chris Alexander Nature of Order: that puts the person ('I') central to design, and other recent research on people-centric approaches – I know Dr Gang Zhao has done some work on this. Requires impact analytics										

13

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?

Relevant Questions												Total No
Is this a valid research question for CDBB and PUN	Yes			✓	✓	✓		✓				4
	No		✓									1
Impact	High					✓						1
	Medium				✓							1
	Low			✓								1
Urgency	Immediate											
	Medium			✓	✓	✓		✓				4
	Low											
Maturity	Mature											
	Medium							✓				1
	Novel				✓	✓						2
Research → Implementation	Mainly research				✓							1
	Balance of Research & Implementation			✓		✓		✓				3
	Mainly											

	Implementation										
Is a key component (>60%) of this work an assessment of current practice?	Yes										
	No			✓	✓	✓		✓			4
Collaboration with industry?	Led by industry										
	50:50					✓		✓			2
	Led by research			✓	✓						2
Comments / Rationale		<p>B: Not totally sure, but I'd assume this is already well addressed by other fields in learning? I think possibly what is meant here is relating to change management issues and criteria.</p> <p>C: Research in this area is needed to establish how to facilitate unlearning if this is at all possible; trying to change people is challenging and how this can be achieved is a very important question. This seems to be easy to talk about but hard to implement.</p>									
Are you aware of anyone leading this area?											

14											
How would a conscious competence evolution lead to agility and resilience in the workforce?											
Relevant Questions											Total No
Is this a valid research question for CDBB and PUN	Yes			✓		✓		✓			3
	No		✓								1
Impact	High			✓		✓		✓			3
	Medium										
	Low										
Urgency	Immediate			✓							1
	Medium					✓					1
	Low							✓			1
Maturity	Mature										
	Medium										
	Novel			✓		✓		✓			3

Research → Implementation	Mainly research			✓		✓		✓					3
	Balance of Research & Implementation												
	Mainly Implementation												
Is a key component (>60%) of this work an assessment of current practice?	Yes			✓				✓					2
	No					✓							1
Collaboration with industry?	Led by industry												
	50:50												
	Led by research			✓		✓		✓					3
Comments / Rationale		<p>A: Two questions; split these!</p> <p>B: How many buzz words can we fit in a sentence ... 'flexible', 'multiskilled', 'adaptive', 'responsive', 'capable', 'competent', 'competitive' are all much better terms for what I think you're getting at. I think almost everyone in the workshop had a problem with the word 'agile'. It may be worth leaving it well alone.</p>											
Are you aware of anyone leading this area?		<p>G: Agile Consortium is doing some work</p> <p>UK Military has done a lot on resilience and I have been involved in big transformation projects.</p> <p>Lots of 'Future at Work' reports on employer demand for resilience but not linked to competency evolution</p>											

15

How does an individual competence development approach allow individuals displaced by the new industrial revolution to thrive and contribute to society?

Relevant Questions													Total No
Is this a valid research question for CDBB and PUN	Yes	✓	✓	✓				✓	✓				5
	No												
Impact	High	✓		✓				✓					3
	Medium												

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