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

January 2019

Authors:

Martin Simpson, University of Liverpool
Professor Jason Underwood, University of Salford
Dr Mark Shelbourn, University of Salford
Debbie Carlton, Dynamic Knowledge
Gulnaz Aksenova, University of Liverpool
Sajedeh Mollasalehi, University of Salford

This project was funded by the Centre for Digital Built Britain.

Executive summary

The Pedagogy and Upskilling Network (PUN) is one of a number of Centre for Digital Built Britain (CDBB) networks of collaborators drawn from research, practitioners and others to contribute to their work with the purpose to:

1. propose the capabilities needed for the UK to deliver and benefit from Digital Built Britain and identify the enabling research to deliver those capabilities;
2. describe the state of the art and leading-edge practice today;
3. build 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) to provide both return-on-investment and succeed as the catalyst for 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 the easiest to achieve than the 'Competence' issues, competency provides a much greater challenge even though 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; reaching out beyond the traditional built environment professionals.
- The mediation of competency supply and demand directly impacts productivity just as much as the flow of timely and appropriate information, i.e. an Information Transaction. However, the proxies used for competence supply and demand are no longer neither granular nor 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 to 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 lack of use. Upskilling and reskilling is the conscious migration of one competency profile to another though education and/or training and/or experience. Furthermore, the competency profile is the pivot of business logic for the competency demand and supply ecosystem stakeholders.
- Furthermore, 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; addressing potential future imbalances (gaps, shortages and mismatches).
- A new digitally enabled ecosystem underpinned by the mediation between competence supply and demand would require new infrastructure (underpinned by research), which does not currently exist. Developing an infrastructure that placed 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; bi-directionally mediating competency supply and demand.
- To address the productivity issue, requires more effective mediation of competency demand and supply (to decrease mismatches) 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 an ecosystem that would facilitate curriculum management to be more competency-based and demand-led. In addition, ensuring academics also assure their own competence as they have as much a need of 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 competences across all dimensions could become liquidities across the ecosystem. Therefore, potentially becoming a disruptive factor across sectors targeting the pressing issues of changing labour landscape and increasing granularity (e.g. team and task-based work) resulting from digitalisation.
- Defining the pedagogy that best suit the upskilling required depends on firstly defining what the upskilling needs to mean in terms of conscious competence evolution and followed by the ecosystem to support a competence-based approach to upskilling that effectively enables the conscious competence evolution.

Acknowledgements

We would like to express thanks to the members of the network for their commitment, dedication and valued contribution to the network.

In addition, we would also like to extend a special thank you to Debbie Carlton for her passions and the sharing of her extensive knowledge.

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1. Introduction

The Pedagogy and Upskilling Network (PUN) was commissioned by Centre for Digital Built Britain (CDBB) to exploring and addressing 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 to both provide return on investment and succeed as the catalyst for evolving the manner in which we conceive, plan, design, construct, operate and interact with the built environment.

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 investments that the Construction Sector and Government strategies and report suggest. McGraw Hill (2014) report 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 Institution of Structural Engineers BIM Survey (2017) reported that 38% of respondents said their firm provided poor or no training. Of those receiving training only 10% reported principal staff and/or Directors being trained in BIM; the majority being either Technicians or Graduates. It is a reasonable statement that 'BIM training' can either mean 'learning to use technology' (the type often being undertaken by junior staff) or 'process focused' with the majority based strongly on the PAS 1192-2:2013 standard (STF, 2018).

Do we do more than "*give people the process and the technology and call those who reject it luddites or laggards*"? (Barley, 2019).

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.

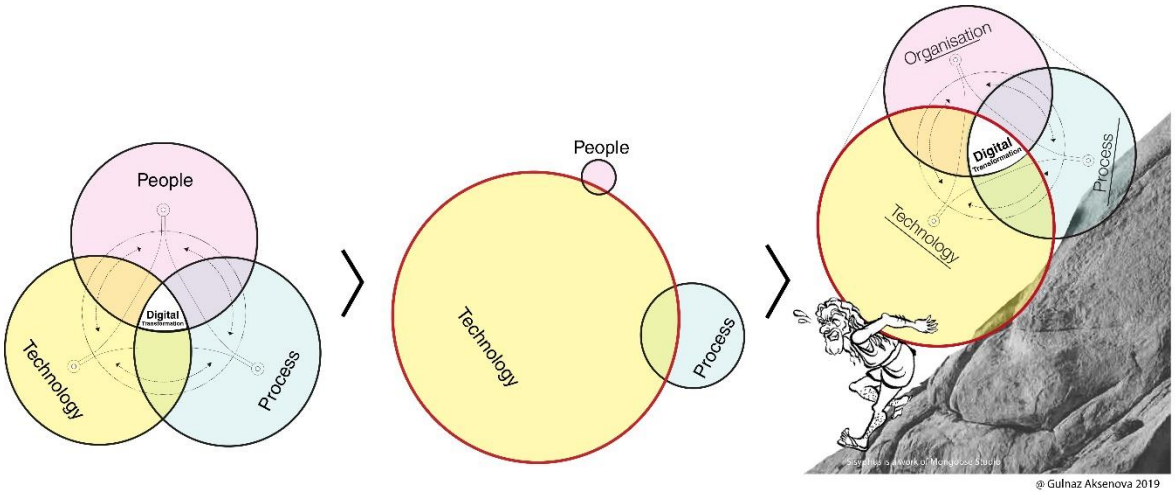

Figure 1. *Relationship between People, Process and Technology and the perceived imbalance in the focus of initiatives (Adapted from Aksenova, 2018)*

The Digital Built Britain vision is far more-wide ranging than that envisaged with 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 from the Grenfell Fire tragedy, the 'Building a Safer Future' report by Dame Judith Hackett (2018) 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, both now and in the future. These systemic failures occur in the delivery of all projects within the Construction Sector and wider Built Environment. The following conclusions from 'Building a Safer Future' are relevant to PUN:

- a competence problem exists resulting from a 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. '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 the easiest to achieve than the 'Competence' issues, which enabled through technology, will provide 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 to ensure a joined-up approach to achieving a comprehensive, coherent and robust framework for the competence of all those creating, maintaining and managing higher risk residential buildings for April 2019.

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' is having appropriate information at hand to make informed decisions within the timeframes expected. However 'competence' ensures that you have the right people who are able 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.

Productivity of people comes from effective mediation between competence supply and demand, and enabled by the flow of appropriate and correct information

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The productivity problems of the construction sector and wider built environment is therefore likely to be to a manifestation of failures relating to the mediation of competence supply and demand, as much as it is 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 effective mediation of competence supply and demand within the Construction Sector and wider Built Environment?**
- **How do we support 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.** To successfully answer these 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 challenges 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 deliver real social and economic benefits to its citizens.

Therefore, it is required to assess the impact 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 company or individual) being 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 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 standards development,
- the citizens that interact and use the built environment for all aspects of their day-to-day life, not just business

In order to be successful, we should ensure we reach out beyond the traditional built environment professionals and include experts from other domains and industries that 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 with regard to 'People'; specifically missing the critical distinction between the 'Individual as a Stakeholder' and an 'Organisation (that comprise of People) as a Stakeholder'. Interventions can be aimed at either the 'Individual', an '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:

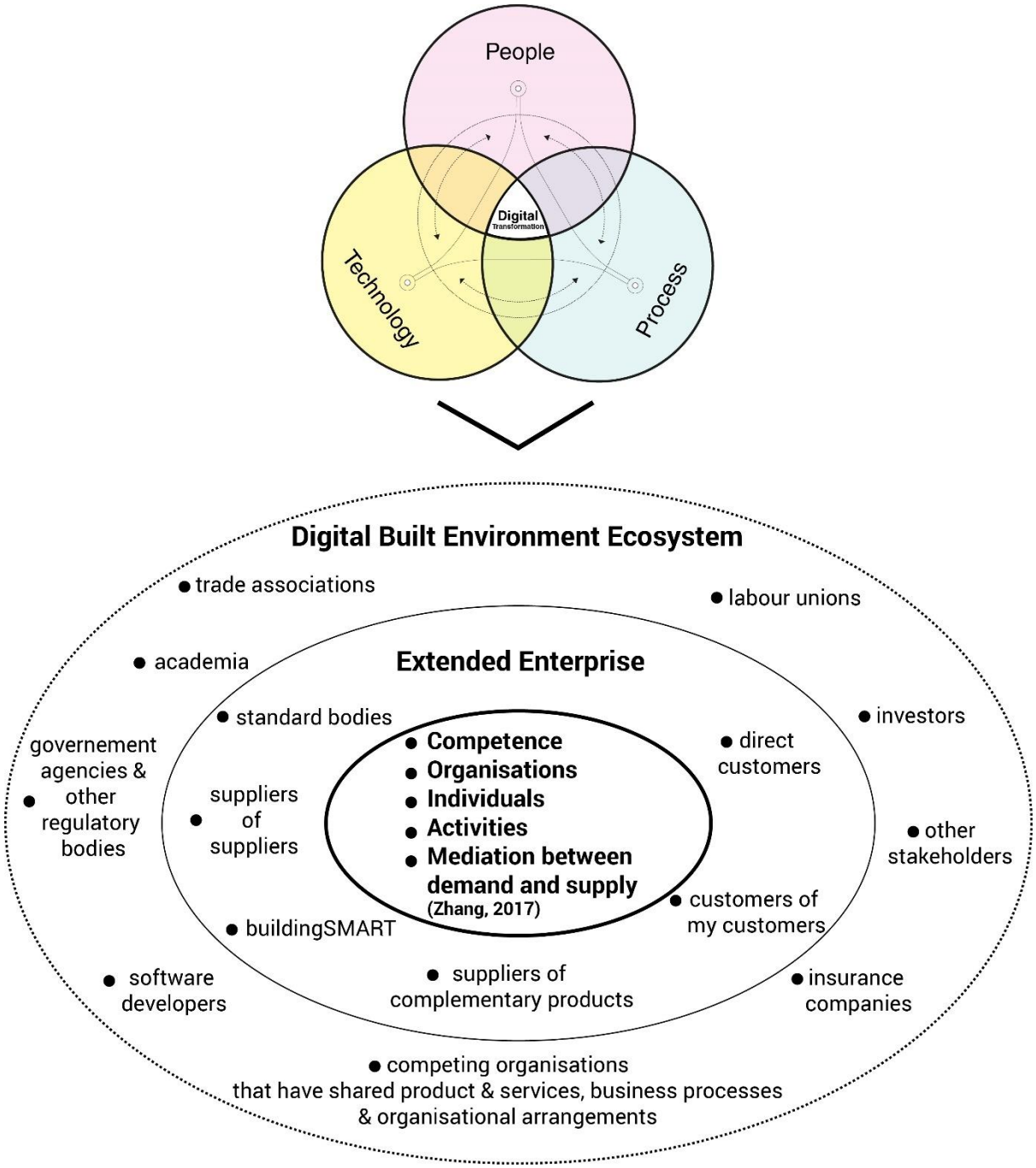

Figure 2. *Proposed alternative to People:Process:Technology (Figure on ecosystem is adapted from Moore (1997) and concepts on an ecosystem of competency mediation between demand and supply are adapted from Zhao (2017))*

Further PUN has categorised proposed initiatives as having a 'Research' focus (TRL 1 → 5) teams or an 'Implementation' focus (TRL 6→9) and though 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 an interdependency 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 long-term impact is possible.

The Ecosystem of the Digital Built Environment has a critical function as it sets the norms of interactions between Individuals to Organisations and Organisations to other Organisations; Process and Technology being 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 overemphasis on technological capabilities in practice and the extensive portfolio of national R&D initiatives targeting mainly the productivity and efficiencies with technological developments did not lead to the systemic change in the established ecosystem nor have led to the emergence of the new Digital Business Ecosystem. As a lesson learnt, the government of Finland has 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, the city stakeholders, the AECO industry stakeholders and the 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) has analysed a knowledge ecosystem creation around the region of Flanders, aiming at stimulating knowledge creation in technology hotspots assuming that these knowledge networks will lead to the competitive advantage of the region. Despite the financial support network, 100% publicly funded, and well-structured knowledge ecosystem, the emergence of new businesses has been almost non-existent. This provided serious implications for policy makers to learn that investment in the creation of knowledge ecosystems does not necessarily lead to the business ecosystems because the value creation processes for knowledge and businesses are fundamentally different. Different types of the ecosystems require specifically tailored policies. Furthermore, Rinkinen and Harmaakorpi (2017) have recognised a 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 Limburg province in the automotive sector to address the cyclical nature of work and keep the skills in the province.

In the context of the growing organizational complexity of Digital Built Environment, driven by their adaptation to high uncertainty, and the central role of collaboration, the ecosystem approach to the Digital Built Environment is becoming of greater importance. A multidisciplinary approach to competency-based management across sectors, disciplines, professions, etc., matters more than targeting the productivity improvement with 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, the current initiatives will have limited impact in terms of innovation (Autio and 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 the other stakeholders of the competence management ecosystem are, therefore, critical if the competent workforce to mitigate the risks. For example, the conclusion from 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 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 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.

3. Competence Supply and Demand

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

OECD (2017b) identified the UK high level of mismatch between skill supply with skill demand due to poor mediation in conjunction with ineffective supply focused interventions facilitated by the UK government (IPPR 2017). 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 that 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 and etc.) are mediators between the supply demand relationships. There is a need to have competency profiles of individuals to understand competency supply and more intelligent analysis of work and the value of work to understand demand. There is increased UK Government focus on meaningful (good) work post the Taylor Review (Taylor Review, 2017). The innovation that is need is how to make the value and meaning of work and competence explicit to aid this. Currently, the proxy for competency demand is occupation and roles. The proxy for competency supply is qualifications. A better articulated demand side of competency can potentially explain the systemic cause behind the low productivity of the UK workforce.

Ultimately, this is a cascading relationship through the entire project/asset supply chain with the primary stakeholders being 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 the 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 it only ever provides the fundamental knowledge or foundations skills or the 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 codes of conduct of Professional Bodies' CPD is about remaining competent to do your work activities, current CPD process do not actually provide assurance of this
- Current certification schemes appear to be limited towards BIM and skills around particular technologies, rather than adopting broader schemes for digital competence, including considering ISO/IEC 17024 scheme development for 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 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 this state over many years. Traditional project delivery methods have failed the construction industry and its clients due to lack of confidence in shared data and incorrect assessments of how to minimise risk and liability. These systemic problems are manifestations of one or more of the following:

- inconsistent exchanges of information at 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
- **failure to engage early with the parties who have appropriate competence to both supply and interpret information on which decisions are to be based. Particularly failure to engage construction and operation specialists early enough in design.**
- deadlines associated with information deliverable are allowed, almost expected, to slip
- inconsistency in the notification of project, both in terms of the information and the timeliness of notification.
- inconsistent communication across the project; both digitally in terms of interoperability and overreliance on written/verbal instructions and feedback which cannot be audited.
- **lack of any consistent framework or infrastructure to facilitate the mediation of competence supply and demand.**
- lack of a both a system/infrastructure for capturing and utilising '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 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 acknowledges and covered by other CDBB or wider industry initiatives.

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

There is considerable history and inertia regarding the professions of the built environment in particular the entrenchment of 'roles' and 'occupations'. This has led to established professions and particularly Professional Institutions with detractors seeing in their conduct and practice a tendency towards protectionism, 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 innovations. Theoretically any organisation can participate in a design or construction project in any location (Langford and 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 not dynamic or 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.

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
- an 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. **Do employers actually know enough about the competences of their workers?**

Over the past twenty-five years, UK skills policy has focused primarily on boosting the supply of skilled or qualified labour. Despite significant progress on this front, UK productivity continues to lag that other OECD countries (Brinkley 2017) with policy in this area being relatively underdeveloped in the UK (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 and 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 'shortage of skills' implies both a recognition that there is a problem and an appetite for policy to tackle the challenge. However despite the 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 the productivity challenges. **Future initiatives should be considered to address BOTH competency supply and in particular competency demand and how to improve mediation and to reduce mismatches.**

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.

The continuous emphasis in the UK on 'skills gaps or shortages' belies a more complex and multi-dimensional challenge around competency mismatches (OECD 2017a). As skills are only one dimension of competence then a best-fit decision to employ and individual based on a skills profile alone may be different to a decision taken on the whole competence profile**. 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 being raised over the increasing gap between digital and non-digital and between high skilled 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 proactive management of this change is closing fast. If the transition towards digitalisation is managed poorly, it poses the risk of widening skills gaps, greater inequality and broader polarization. (World Economic Forum, 2018a). Furthermore, the industry does lack the dynamic capabilities to build the necessary competencies for the digital transformation (World Economic Forum, 2018b). A greater shift from 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 both acts to constrain the skill/competence composition of 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 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 competences 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 how effective the individual is at the day-to-day activities required as part of their 'role' or 'job' or 'task'. *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*. 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 our different activities.

Activities are the fundamental building blocks of work

Note: For the purpose of this report an 'Activity' has a definable and intentional result.

When we look at Built Environment projects, which involve multiple organisations collaborating and contracting with each other, 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

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Projects are a collection of activities

We have recognised the potential that consistent structuring of information could have to 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 broader uptake.

Furthermore, the report by Bush and Robinson (2018) for the Scottish Futures Trust was investigating the challenges of "*Developing a BIM Competency Framework*" based on traditional occupational roles, whereas the scope for Digital Built Britain is significantly more comprehensive than BIM moving towards a digital transformation within Digital Built Environment ecosystem.

The challenge lays within the demand side to become a more responsible and intelligent actor in this mediation. As IPPR (2017) has pointed: "*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*". The clear client requirements and value definition in projects have been a missing point as well as the ineffective old procurement models (Mosey et al., 2016). Consequently, clients do not know what competences to demand nor have capabilities to lead and define the value they need, and therefore clients themselves require certain competences in order to fulfil the activities associated with the client 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 competence gap, shortages, and mismatches on productivity and 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 granular 'activity' classification of work.

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

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

A fundamental aspect of Competency Demand is Competency Definition

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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 done and finally 'who by' 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 assemble a competent team based on these requirements and assure the competence of the team to the client (or the stakeholder to whom competence is being supplied).

Compare this with the workforce planning on the majority of large Built Environment projects (p. 12) *"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', a team, a workpackage, a project, an organisation and even across the whole industry/sector. This could provide far better data to support policy to address shortage, supply and mismatch of Skills (or Competence)

'Skills mismatches' are where individuals are mismatched to their jobs in terms of competences, or qualifications or field of study (discipline). The mismatch can be over-skilled or qualified or under-skilled or qualified for example 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. Yet most training (both initial professional and CPD) is generic meaning there is considerable waste (time and money) in the trainee attending courses for a small subset of the content actually required. Moreover, unless knowledge/skills is not quickly applied and reinforced by experience, the knowledge/skills are lost.

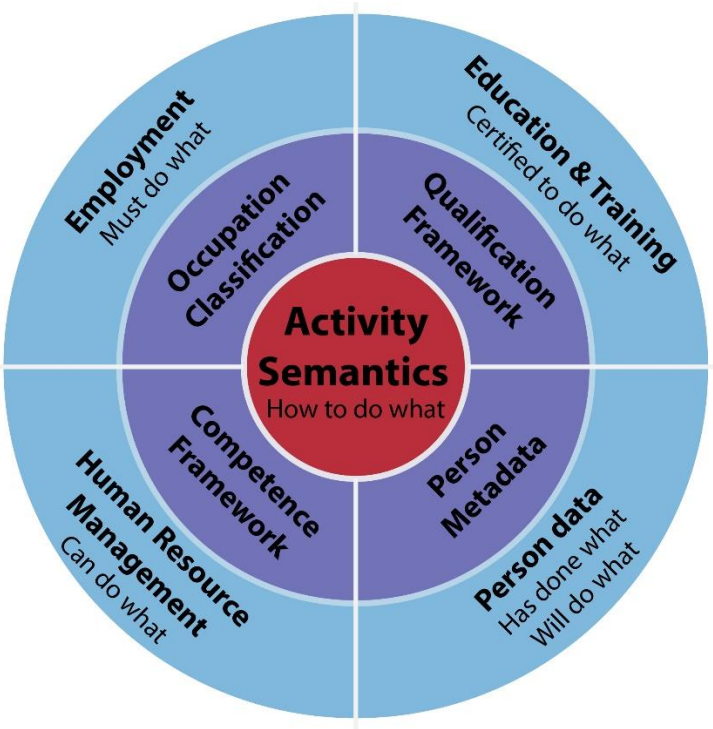

Figure 3. *Adapted from Core of Competency [© Interlates, see Zhao, 2017a]*

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

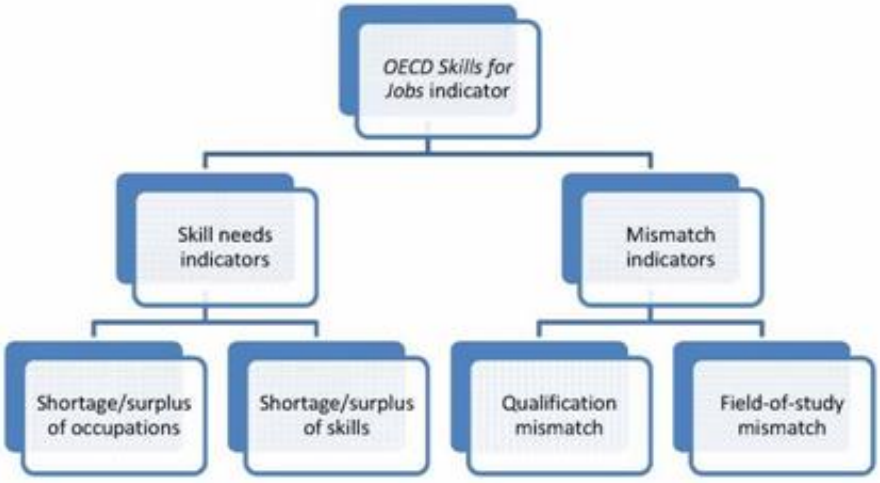

Figure 4. *The structure and components of the OECD Skills for Jobs indicators*

The Competency Profile of the Individual is not static. Certain competences can grow and other diminish through lack of use. This is not immediately obvious to either the employer or the individual. An infrastructure which 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 the perspective of managing their future career. Developing an infrastructure that placed the needs of the individual at the centre of the initiative would be a new paradigm.

Upskilling (and reskilling) is the conscious migration of one competency profile to another though education and/or training and/or experience.

Upskilling is the conscious migration of one competency profile to another (Zhao, 2018)

The competency profile is the pivot of business logic for the 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, both of which 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 can be thought of as 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 in defining competences across sectors and countries which are overlapping. Competency management can potentially target this issue if the efforts are coordinated across the ecosystem. A universal matrix of competences across the ecosystem stakeholders would allow knowing what competences are required in the labour market.

3.3 Competency as currency in the labour market

Central to productivity is people; competency of the current and future workforce. If individuals and employers had the infrastructure and a digital enabled ecosystem within which to transact on the basis of competence, then competence would become 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 possess as a computation unit can become a new currency in the market. This potentially can become a disruptive factor across sectors targeting the pressing issues of changing labour landscape and increasing granularity with digitalisation and capabilities such as activity semantics (Zhao, 2012). There must be a shift from traditional professional disciplines, roles and occupations that evolved through siloed career paths to supporting career portfolio based on competency management.

With current infrastructure based on the occupational roles, the employers rely only on the reputations of the educational institutions and professional bodies to assess the competency of its employees.

The current pressing issue in the changing labour landscape is that the competent individuals are increasingly responsible for managing their own career moving from one profile to another. A key issue is the individuals / employers have no infrastructure to transact in the marketplace or to manage their career portfolio data (Zhao, 2014) nor individual is 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 be delivered with a people-centric approach (Zhao, 2018).

The key is value and meaning of work where attributes of competence in relation to why, how and what become critical to meaningful work, engagement and self-actualisation and improving productivity and reducing risks as pointed by Skills Review Group (2018). The CPD, professional, trade and education bodies are not fit for this purpose as evidence shows (Ball, 2008; Hughes and Hughes, 2013; Morrell, 2015; Uff, 2016; Skills Review Group, 2018).

Furthermore, it would empower individuals to be responsible for their Conscious Competency Evolution and allow employers to both recognise and reward innovation. This needs to be underpinned by a shift from predominant supply-side policies and interventions to **a people-centric approach** to improve mediation and matching of people to meaningful work to improve productivity. Consensus on foundational definitions and guiding values must be established to begin enabling 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

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

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

- A **Competence Framework** to enable consistent **Competency Definition** for a particular activity
- The ability for individuals and teams to assess and evidence their personal **Competency Profile** and 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 to in turn 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 Competency Profile Evolution. This does require curriculum management to be competency-based
- The ability for professional institutions and trade organisation to take a more informed view as to the Upskilling requirements of their members and 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 having gaps and deficiencies in the profile of the workforce. 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, securely shared in a transparent and auditable manner

- The ability for government to understand the true imbalances in competence and 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 for bi-directionally mediating competency supply and demand. It enables the analysis of competency state and evolution in order to facilitate the match of competency supply and demand, the fulfilment of competency needs by competency development, competency planning, migration and assurance.

This approach is ideally suited to Artificial Intelligence (AI) and Machine Learning (ML) which could enable unbiased approaches to enable definition, collection, comparison, extension and evolution of competences and are scalable to other contexts (Zhao and Carlton, 2015). Traceability, accountability and verification/assurance is required to provide confidence in the infrastructure.

AI analytics of competencies presents the opportunities for the DBB organisations to enable an environment in which the 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 truly a stakeholder yet.

The infrastructure can provide the opportunities to increase the transparency of competency data on individuals and organisations. The currently available data is mostly not transparent, unstructured and distributed. In fact, organisations know very little about their workers and competences needed 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 classifications.

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

The evidence shows that the environment comes more turbulent, dynamic and complex. The boundaries of professional occupations and roles are becoming blurry. Architects have started to compete with surveyors and general contractors (Langford and Male, 2008, World Economic Forum, 2018a, World Economic Forum, 2018b).

Competent people are a source of innovation and productivity and 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 to be responsible for managing their own career through Conscious Competency Evolution

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

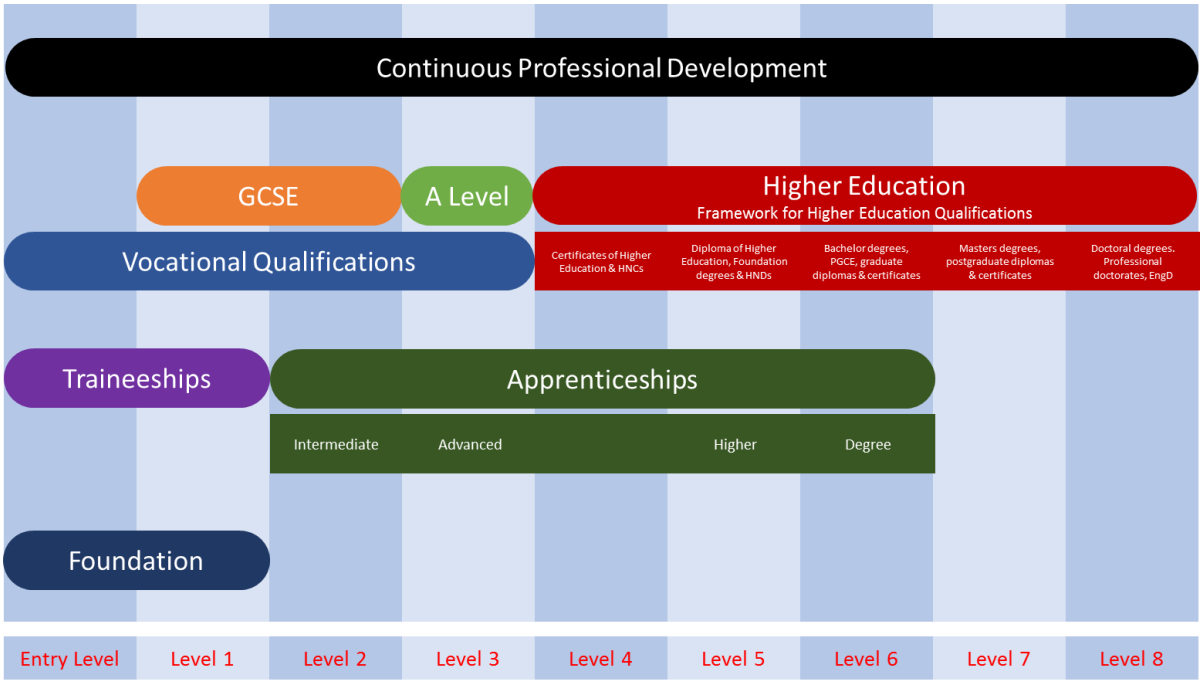

Figure 5. *Phases of lifelong learning*

It is not the scope of PUN to address Pre-18 education, however it was recognised that much more needs to be done address the poor image of the industry and prevent the talents of the next generation from being siphoned away from Built Environment professions. Key areas of action are:

- Improved career advise
- Initiatives, e.g. DEC[1]
- Greater involvement of the profession with schools

[1] https://designengineerconstruct.com/what-is-dec/

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

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 stated (2007) 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 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 General Medicine degree prior to specialising in a particular branch of medicine.

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 effective in silo mentality as the construction industry. This is leading to some calls for a new medical 'specialism' to take a 'systems integration' approach to coordinate the different specialists. For example, Cook and Chatterjee (2015) suggest that there is an increasing need for interdisciplinary working and leadership capabilities in the Built Environment.

It should be noted that the silo mentality exhibited by HEI's is a direct response to the accreditation of their courses by specific professional intuitions. Furthermore, it is accepted that HEIs have limited scope for innovation if their courses are to be accredited. Several academics at the workshop stated that whilst there is desire to innovate, the procedures for major changes to programmes and modules resulted in a risk-averse strategy with considerable pressures to meet accreditation requirements within the constraints of the current system. In addition, this is further exacerbated by lack of technologies in curriculum management; where competence demand can be understood more explicitly. Many HEI's 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 success in grants and publications. In many HEI's, research specialists are expected to also deliver teaching modules. This may be acceptable for theoretical modules, however Built Environment courses often have significant elements of vocational training that require knowledge and experience of current and evolving industry practise. As we move to 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 pressure from industry to increase these aspects in the course are met by the constraints of suitable space, staff-student ratio and the competence and experience of the 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 build capacity for a transforming industry (Farmer, 2016).

The BIM Learning Outcome Framework (BSi, 2019) aimed to facilitate consistency in the development and delivery of digital-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 on breaking down and establishing 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 and the development of their competence to drive change in the current curricula and align with the needs of the next generations of learners (BIM2050, 2014). As is similarly evident in industry, the understanding, acceptance and importance of digital transformation amongst Higher Education (HE) academics within the built environment, engineering, architecture, etc. is still considerably low (BAF, 2015; NATSPEC, 2014, 2015, 2016, 2017; 2018, Underwood, 2014). Therefore, changing such culture and mindset that exists among many academics presents 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 (siloed minded) professionals (BIM2050, 2014). Moreover, there is still considerable short of an ecosystem that would facilitate curriculum management to be competency-based. In addition there is the question of how we ensure the academics who develop and deliver courses also assure their own competence. The academics have as much need of conscious competency evolution as the industrialists.

Those case studies (RAEng 2010) demonstrate exemplar engagement between industry and universities, there is a lack of data to show whether this is a consistent story or whether for some the only interaction occurs through occasional meetings of their Industrial Liaison/Advisory Committees.

It was discussed at the PUN workshops whether Universities should play a much more significant role in 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 the various levels of education, in the main, the approach tends to be ad hoc and without consistency. Furthermore, 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, rather than being set as a strategic objective at a school/department or institutional level (BAF, 2015; Underwood, 2014).

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 of a true collaboration between industry and academia in the upskilling of the workforce, or simply a day-release under another name.

4.2 Lifelong learning, CPD and Professional Institutions

The Professional Institutions have evolved in a manner that reinforces the siloed thinking within the Built Environment. This is a direct response to both protect their members and act 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 the professionalism as professions create cognitive frameworks within their jurisdiction and only seek control (Hughes and Hughes, 2013).

The Professional Institutions set the requirements for the degrees they accredit both directly and for some, indirectly through their input into the UK Standard for Professional Engineering Competence (UKSPEC). As such, they influence FEIs and HEIs 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) state that the current CPD model is not a fit model 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. CPD is problematic in multiple ways:

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

CPD requirements should be urgently reviewed to establish a more robust system which ensures that a member's qualification remains relevant to their work and aspirations and up-to-date throughout the member's career.

The Professional Institutions and Trade Organisations are the key players in specifying 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. Multiplicity of institutions and their siloed nature that cannot agree on a common issue even if it is a public good is a common struggle in the industry. This high fragmentation creates challenges for the Leadership Council to address multiple voices, consequently it is taking a neutral position that is leading to no change. The professions have been poor at collaboration at an institutional level (Morrell, 2015). The characteristics of their business models are contradictory to what the Industry Leadership Council hoped to achieve. Hughes and Hughes (2013) and Morrell (2015) call 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 the engineering institutions are beginning to collaborate towards addressing the competency assurance issue. 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 the one providers 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 current, never mind emerging, competence.

This is not to disparage CPD provision, but 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 attendees of courses 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 trying to cover a wide range of topics in the hope that all attendees will take home something they find useful. There are no real examples yet of dynamic competency-based CPD planning, although ICE has done 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 skills retention decays. Therefore it is questionable whether any CPD that is not directly relevant to their day-to-day activities is of benefit.

CPD provision is usually multiples of half days, with many courses taking a full day. This time actively discourages Individuals who are Sole Traders and/or from Micro SME's as the time to attend courses is taken directly from fee-earning capacity. However, a significant proportion of the workforce of the Built Environment (both in terms of construction and professional services) is Micro SME/Sole Traders.

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

4.4 Unlearning: Selecting an alternative mental model or paradigm for enabling 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 been focused on the wrong thing, whereby the problem is not learning, but in fact, it is unlearning. In every aspect of business, we are operating with mental models that have grown outdated or obsolete, from strategy to marketing to organisation to leadership. To embrace the new logic of value creation embracing all that digital allows, we have to unlearn the old one. The misconception is that unlearning is about forgetting, whereas 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 one.

In this 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 upskilling. However, it became quickly apparent that the logical order for the industry would be to:

1. Define what upskilling needs to mean in terms of competence, in particular conscious competence evolution.
2. Define the ecosystem to support a competence-based approach to upskilling and enable 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 research questions that need further research. If these questions are addressed in future research activities, then the network is confident that the Pedagogy and Upskilling aspects of Digital Built Britain can be realised.

The table here shows a summary of the key research questions. It has been structured to demonstrate:

- The level of potential impact from answering that question.
- How urgent is the research needed?
- What is the current level of maturity of research (ie what research already exists to cover the research)?
- 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 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

Considering table 1, it can be determined that there are seven questions in the IMMEDIATE term that need to be addressed in the first instance. The network has determined that in answering these research questions there is a potential for HIGH impact on the industry. Out of these seven questions there is a medium level of MATURITY in current research that already exists.

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

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

B. How does curriculum development need to adapt to align to a 'collaborative competence management' approach?

C. If the fundamental question is about empowering individuals to consciously evolve from one competence profile to another, then what is the infrastructure, technology and processes required to facilitate/enable this?

Question 8 has been deemed to be low in immediacy by the network. This is due to the makeup of the network being industry biased. Having considered the nature of the question it has been deemed to be very important to the development of the education side of research. The question is:

A. How does education need to adapt to becoming 'demand led' and 'competence based?' – is current university education fit for purpose?

B. 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 bullet point **A** the following subset of questions need to be addressed:

i. 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 limited effect. What is the best way of redressing this?

ii. 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?

iii. 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?

iv. 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. 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:

A. ‘Upskilling’ typically implies a ‘skill gap’, but it 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 ‘individual’s competence development’ and ‘competence management’?

B. The UK suffers from poor data relating to the 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”?

C. 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?

D. For 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?

E. How does “conscious competence evolution” lead to “agility” and “resilience” in the workforce?

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

Questions **A** and **B** have had some research already conducted and documented, some of this has been identified in this network. Questions **C** to **F** 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 research ‘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:

A. What and how to enable individuals to thrive in the workplace and have 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 to make from the results of the research questions is to see that any further research activities in this area NEED both the industry, academia and other complementary but important institutional stakeholders related 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 the institutional silos, this leads to a more successful outcome being achieved.

The research discussed here is necessary to enable Digital Built Britain to be achieved.

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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(ces) and competency(cies) is made...the latter is the collective noun of the former' and consistently stick to competence, competences and competency[2]

An activity is a major unit of work to be completed in achieving the objectives of a process. An activity has precise starting and ending dates, incorporates a set of tasks to be completed, consumes resources, and results in work products. Understanding 'activity' is fundament 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) :20. 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)): It is an ability demonstrated in an activity at work. It has multiple aspects, 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 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 that define a firm's fundamental business as core. Value can be enhanced by combination with the appropriate complementary assets to which degree a core competence is distinctive depends on how well endowed the firm is relative to its competitors, and on how difficult it is for competitors to replicate its competencies. Core competence is a communication,

[2] "*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.

involvement and deep commitment to working across organisational boundaries. It involves many levels of functions and people (Prahalad and Hamel, 1990).

Capability is defined as a complex combination of appropriate set of competences towards achieving specific organisational objective(s). It emphasizes the key role of strategic management in appropriately adapting, integrating, and re-configuring internal and external organisational skills, resources, and functional competences toward 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). That is why dynamic capabilities are conceived as routines/activities/competencies embedded in firms (Eisenhardt and 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: p. 42).

Job is an instantiation or extension of a role(s) for a specific context. A job can have 'n' roles but increasingly organisation is moving away from planning based on roles to more 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, miniaturization 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 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 so you can do a different job, or of training people to do a different job.[3] To enable transition of workers from adjacent sectors, profession or disciplines that require reskilling. Reskilling is the evolution of one competency profile to another

Role is an aggregation of activities that a person carried 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 profession or activity. This role belongs to that profession. This activity requires these roles to perform; not a one to one relationship.

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

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

Upskilling is the process of learning new skills or of teaching workers new skills[4]

[3] https://dictionary.cambridge.org/dictionary/english/reskilling

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 own use. This includes own-use production work, employment, unpaid trainee work, volunteer work or other forms of work (ICLS, 2013)

[4] 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 Construction Leadership Council (CLC) or 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 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	The procurement processes, in particular how competence supply and demand is defined and managed as well as assessed and allocated
TRL	
Timeframe	
Prerequisites	
Notes	
E.3	The funding process, in particular how risk could be managed in relation to the confidence in the competence of those delivering the project
TRL	
Timeframe	
Prerequisites	
Notes	
E.4	The innovation process, in particular how we can 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 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		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? C: This is a fundamental question to be answered to achieve the PUN objectives and to develop the theoretical framework										

		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?		B: Depends which competence model you're looking at, see the newly release CIPD Professional Map! E: Elizabeth Kavanagh, Behaviours4Collaboration – someone who actually understand this in the context of construction Alison Watson, DEC in Schools – passion for improving the industry G: Dr Gang Zhao & myself Oil & Gas Sector University of Plymouth did short research paper I contributed to as part of Innovate UK Skills Planner project	

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

	Mainly Implementation	✓										1
Is a key component (>60%) of this work an assessment of current practice?	Yes		✓		✓	✓		✓				4
	No			✓			✓					2
Collaboration with industry?	Led by industry	✓										1
	50:50		✓	✓	✓	✓	✓	✓				6
	Led by research											
Comments / Rationale		B: This is a great question for me as an L&D professional, as technically those involved in this type of role should be key facilitators of competency across organizations, whilst it would be an interesting topic to explore, not sure how much benefit it would yield to the wider industry?										
Are you aware of anyone leading this area?												

3

"Upskilling" implies a "skill gap", where competence is a function of education, skills, experience, behaviours etc. The general consensus is that the built environment sector has a "competence gap". So what is "upskilling" in the context of "individual's competence development" and "competence management"? (Is "upskilling" even the right word?)

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

	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		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. C: Identification of a set of skills required for BE professionals is important before looking about upskilling. Upskilling requires assessment of current practices and then comparing with what is required. I do not think upskilling is appropriate as this references more to the development of existing workforce and hence it may not be inclusive.										
Are you aware of anyone leading this area?												

4

The general consensus is that "competence" is <u>activity</u> based, not <u>role</u> 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		A: New philosophy, less role dependant 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. C: Activities are linked with roles, not sure the statement is accurate about the consensus about the definition of competence. F: My feeling is that the industry is already quite well served by definitions of activity based competence, through the professional bodies.										
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		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**.										
Are you aware of anyone leading this area?		G: Dr Gang Zhao, Intelartes and myself. ICE done some work with us on this Innovate UK Funded project – SkillsPlanner										

		built some capability but too high level to aid useful matching as not competency based	

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 which 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 Uni – 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 → Implementation	Mainly research			✓								1
	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, 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 relate to becoming "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		A: too broad B: Useful question for follow up but again I see this links to a primary need for a 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 standard, well-defined assessment criteria. 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 which is not really focussed on or unique to the challenges of digital built Britain.										
Are you aware of anyone leading this area?		E: To an extent Network Rail Challenge Statements, see link below										

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		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. 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 F: This could be better focussed with some specific emphasis on digital built Britain.										
Are you aware of anyone leading this area?		G: In terms of making meaning explicit – Dr Gang Zhao										

10

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 blockers?

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		A: feel there is evidence at this element more important to focus on the new ways of working rather than reengineer the old. 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. 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 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 focussed 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 MottMac.	

11

If the fundamental question is about empowering individuals to consciously evolve from one competence profile to another, then what is 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 industry?	Led by industry											
	50:50		✓	✓	✓	✓		✓				5
	Led by research											
Comments / Rationale		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 affordability of retraining, and the desirability of the people in the industry to change to this model are of critical importance. 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?										
Are you aware of anyone leading this area?		G: Dr Gang Zhao A lot of employability portfolio studies in UK and Europe										

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 →	Mainly research			✓	✓			✓				3

Implementation	Balance of Research & Implementation					✓						1
	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: 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 & other recent research on people-centric approaches – know Dr Gang Zhao done some work on this Requires Impact analytics										

13

For 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			✓		✓		✓				3

	Research & Implementation											
	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		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. C: Research in this area is needed to establish how to facilitate unlearning if this is at all possible, try to change people is challenging and how this can be achieved is a very important questions. This seems to be easy to talk but hard to implement.										
Are you aware of anyone leading this area?												

14												
How does "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		A: too questions, split out! 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.										
Are you aware of anyone leading this area?		G: Agile Consortium doing some work UK Military done a lot on resilience and I have been involved in big transformation projects Lots of future at work reports on employer demand for resilience but not linked to competency evolution										

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											
	Low		✓					✓				2
Urgency	Immediate			✓			✓					2
	Medium	✓	✓					✓				3
	Low											
Maturity	Mature	✓	✓									2
	Medium							✓				1
	Novel			✓			✓					2
Research → Implementation	Mainly research		✓	✓								2
	Balance of Research & Implementation						✓	✓				2
	Mainly Implementation											
Is a key component (>60%) of this work an assessment of current practice?	Yes						✓					1
	No		✓					✓				2
Collaboration with industry?	Led by industry											
	50:50			✓				✓				2
	Led by research		✓				✓					2
Comments / Rationale		B: Good question, but low impact. Thinking there must be lots of case studies of how new skills replace old ones and the impacts of that (see anything relating to the impacts of manufacturing automation for example) that can be referred to in answering this question without setting off on a new path of discovery? C: I am not sure whether there is sufficient evidence available to suggest people have been displaced, however, it will be important to establish how individuals have changed themselves to adapt and develop themselves. F: This question is good, as it places the challenge very much within the context of current industrial change, and could have an impact on education, practice and professional development.										
Are you aware of anyone leading this		G: CITB doing work in the displaced/disengaged area as our lots of										

area?		charities Initiatives like BuildingPeople I have been involved in Recent Nesta research	

Network Contributors

Gulnaz	**Aksenova**	University of Liverpool
Samuel	**Allsopp**	Operam
Zeeshan	**Aziz**	University of Salford
Chunli	**Cao**	Green Crane Consulting
Debbie	**Carlton**	Dynamic Knowledge
Mustafa	**Cidik**	London Southbank University
Paul	**Coates**	University of Salford
Ricardo	**Codinhoto**	University of Bath
Andrew	**Crossley**	University of Bristol
Sarah	**Davidson**	University of Nottingham
Ray	**Elysee**	Ray Elysee Associates
Abdulkadir	**Ganah**	University of Central Lancashire
Rob	**Garvey**	University of Westminster
Mohamad	**Kassem**	Northumbria University
Elizabeth	**Kavanagh**	Stride Treglown
Bimal	**Kumar**	Northumbria University
Richard	**Laing**	Robert Gordon University
Ramesh	**Marasini**	Solent University
Dianne	**Marsh**	Liverpool John Moores University
Mark	**McKane**	Ulster University
Maryam	**Mollasalehi**	University of Salford
Peter	**Monaghan**	Southern Regional College
Fiona	**Moore**	Cirrus Consultant Services
David	**Morton**	Northumbria University
Jim	**O'Connor**	Galway Mayo Institute of Technology Ireland
Eleni	**Papadonikolaki**	University College London
Sascha	**Peter**	Arcadis
Michael	**Ramage**	University of Cambridge
Duncan	**Reed**	Trimble
Peter	**Routledge**	Whitefrog
Kirti	**Ruikar**	Loughborough University
Mohammad	**Saki**	University of Greenwich
Noha	**Saleeb**	Middlesex University
Gareth	**Sewell**	BRE
Mark	**Shelbourn**	University of Salford
Martin	**Simpson**	University of Liverpool
Terry	**Stocks**	Failthful & Gould
Jason	**Underwood**	University of Salford
Alison	**Watson**	Class Of Your Own
Ann	**Woulfe**	Mott MacDonald