

SYNTHESIS

A reform agenda for UK construction education and practice

Gavin Killip¹**Abstract**

Achieving zero carbon requires major changes in buildings and construction practices, but both remain very hard to achieve. The UK construction sector operates in a low-skills equilibrium, whereby poor quality assurance and significant design–performance gaps accompany low educational attainment and low wages. Skills debates often focus too narrowly on the supply of skill, but consideration also needs to be given to skill demand and use in the workplace. An evaluation framework for zero-carbon construction is proposed in which types, orders, and domains of learning are explained and differentiated. Competence is presented as a bundle of learning attributes including theoretical knowledge, practical skill and integrity of character. Each type of learning operates in hierarchical orders and can apply in different domains: from the narrowest focus on individual tasks to broader domains of occupation and industry. This evaluation framework is used to analyse previous research with low-carbon pioneers, showing how higher orders of learning need to be applied on projects, in firms, networks and business models. If the construction industry is to achieve these levels of learning, and apply them regularly in mainstream practice, then fundamental changes are necessary to the structure of employment as well as educational reforms.

Policy relevance

The UK construction sector currently operates in a low-skills equilibrium which negatively impacts the capabilities to produce low-energy buildings. Research with low-carbon pioneers shows how higher orders of learning need to be applied to projects, in firms, networks and business models. Higher levels of occupational competence should be the goal, combining theoretical knowledge, practical skill and quality of character (acting responsibly and with integrity). The achievement of higher level competences in mainstream practice will require significant changes to the structure of employment involving labour market reforms and higher levels of accreditation and professionalisation of construction vocations. Meaningful educational and training reform requires industry reform at the same time to create the appropriate demand pull.

Keywords: construction industry; industry reform; labour; low carbon; vocational education and training; zero carbon; UK

1. Introduction

A zero-carbon future in the UK is consistent with profound changes in energy supply coupled with deep reductions in energy demand across all sectors, including buildings (Eyre & Killip 2019). However, despite there being decades of policy and research dedicated to showing that much better is possible with current technology, the reality is that shifting the built environment towards a low-carbon future remains extremely difficult in practice (Lowe & Oreszczyn 2010). In a review of over one hundred studies on the design–performance gap in new housing construction, the Zero Carbon Hub (ZCH) found three broad causes of under-performance, all linked to processes and practices rather than a scarcity of technology: a lack of technical knowledge on project teams; poor communication; and unclear roles and responsibilities (ZCH 2014).

In response to such findings, calls for more and better training are not hard to find, but, as this paper seeks to demonstrate, when the problem is framed solely in terms of skill supply without regard for real demand for skill in the workplace, it does not stand a chance of being genuinely transformative. What, then, are the key issues for skills

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training and education in the policy-led push to deliver buildings with long-term and low-carbon energy performance in the real world?

Construction is far from being a homogeneous sector, covering as it does everything from handyman services to major infrastructure projects. There are different types of buildings, different types of firms, new-build and renovation projects. In terms of the workforce and workforce education, a key distinction is between professionals (designers, project managers, consultants) with university-level education as opposed to on-site construction workers, who may have vocational education and training (VET) at different levels, be apprentices or have no formal training at all.

The underlying challenge (which predates concerns about building energy performance) is one of quality assurance in an industry characterised by fragmentation, poor quality and poor customer service (Egan 1998, 2002). Appeals for the wholesale mechanisation of the construction process (*e.g.* Farmer 2016) are misplaced because construction is different from mass manufacturing: it is a 'complex-product industry' where projects and project teams are largely bespoke, and small changes in one aspect of the work may lead to large impacts elsewhere in the process (Winch 2003).

Nevertheless, there is a growing body of evidence featuring innovative projects, firms and business models where much better end results are being achieved than is typical in mainstream practice (*e.g.* Fawcett & Killip 2014; Mlecnik, Straub, & Haavik 2017; Johnston *et al.* 2016). Understanding these innovations in detail, and analysing the ways in which they diverge from mainstream practice, carries the potential of identifying meaningful reforms and making net zero a reality at scale.

The main focus of this paper is on the social organisation of craft trades doing work on-site in the UK. That is not to deny the importance of design professionals and others in the many and varied processes of construction, but the role of the craft-based workforce in delivering and maintaining a zero-carbon built environment remains relatively little researched. The social and economic organisation of the construction workplace needs to take account of the craft-based workforce if the zero-carbon policy objectives are to be met.

The paper proposes a framework for the debate about skills for zero carbon in the built environment. It draws on literature from construction management, educational theory and energy studies to address three related policy questions:

- How does VET operate in the UK construction sector?
- How can the meaning of 'skill' be refined and explained in relation to zero-carbon and mainstream practice?
- What lessons can be learned from analysis of innovative good practice?

The paper is organised as follows. The next section summarises the broad economic and social context of construction. A brief overview of VET for UK construction is then presented. This is followed by a discussion of the interdependencies between demand, supply and use of skills. An evaluation framework for low-carbon construction is then proposed, drawing on a selected review of relevant literature from educational theory, construction management and energy studies. The framework is then used to analyse the capabilities of pioneers, *i.e.* those who have achieved good-quality outcomes in projects, networks and business models. In the discussion section, the main points are summarised, and practices of pioneers are contrasted with the mainstream using the lens of the evaluation framework proposed in the paper. The implications of this analysis for policy are summarised in the conclusions, making reference to the types of reforms needed and pace of change that might be possible if the construction industry is to play a meaningful role in delivering a zero-carbon buildings sector.

2. The economic and social context of construction skills

Despite having positive associations in general use, 'skill' cannot be taken for granted as a priority or even a desirable goal for business. Indeed, firms may make a strategic commitment to not invest in skills, preferring to operate in low-margin, high-volume markets, where costs are kept down by concentrating on low quality at low cost (Keep 2016). This strategy can be profitable and therefore durable. Green (2016) identified this tendency in the construction sector and dubbed it the 'low-skills equilibrium', showing how low demand for skills is a stable factor in a market where there are also low wages, little job security and low prestige. Construction is a sector with a problem of false self-employment, which leads to what Behling & Harvey (2015) term 'degenerative competition': a situation where subcontracting small firms do not have the resources to invest in their own development and the larger contractors avoid the responsibility for doing so. This comes about because the workforce is not directly employed, despite the relationship between contractor and subcontractor having many of the characteristics of employment.¹ Such market freedom comes at the price of reduced tax income to the state, a failure to invest in skills, endemic poor productivity and a culture which is antithetical to innovation (Behling & Harvey 2015). This situation reflects a conscious choice among construction industry leaders to prioritise flexibility of response in a cyclical 'boom-bust' market rather than investment in long-term human resources development (Dainty, Green, & Bagilhole 2007). The delegation of responsibility for VET to the small-scale subcontractor is effectively passing the decision to the individual unskilled worker:

who is least likely to have information, resources or inclination to embark on a lengthy training programme. [...] Without a genuine and sustained commitment to workforce investment, construction careers and occupations will remain a last resort for many of those whom the industry needs to attract. (20)

Halting this culture of degenerative competition requires structural changes, with actions that tackle market failures, not just the supply of education and training. Green (2016) proposes a mix of demand-side and supply-side policies, which need to be sensitive to sectoral and geographical context, in order to overcome a low-skills equilibrium:

- public procurement to help stimulate demand in new markets;
- intentionally changing the local model for economic development;
- collaboration and networking across firms, focusing on firms' competitiveness strategies;
- job redesign and worker engagement to make better use of skills;
- collaboration with universities and colleges to build technical and management capabilities;
- broad partnership working, facilitated by well-engaged intermediaries.

These proposals broadly match two, potentially complementary, schools of thought about how to tackle the low or patchy demand for skills (Keep 2016):

- Closer integration of skills within broader economic development and business improvement and support strategies.
- Policy levers and incentives that can help shift firms' competitive strategies upmarket in order to engineer an increase in their need for skilled workers.

The relevance of these reports by Green and Keep to the zero-carbon agenda is the insight that skills development, jobs availability and economic development go hand in hand. Addressing the skills issues alone will not be sufficient if the economic conditions do not provide for relevant prospects of employment; nor will economic initiatives to create jobs be successful if the available skills do not meet the job requirements.

Keep himself acknowledges that this joined-up approach involves greater complexity than a narrow focus on skills supply because it means getting to grips with 'the often messy way that economic, business, workforce development and industrial agendas intersect' (Alcorso & Windsor 2008, cited in Keep 2016: 5).

3. UK vocational education and training (VET)

Official government statistics for workforce qualifications by job type are only reported in terms of very general classifications: 'construction of buildings' and 'specialist construction activities'. Education is a devolved policy matter, which makes comparison difficult between England, Scotland, Wales and Northern Ireland. In England and Wales there is a system of work-based national vocational qualifications (NVQs) that operate at different levels in the Regulated Qualifications Framework. Although there is no formal equivalence between work-based and academic qualifications, NVQ level 2 corresponds broadly with the top grades (A–C) in school examinations at age 16 (General Certificate of Secondary Education—GCSE); and NVQ level 3 corresponds broadly with school examinations at age 18 (A-Levels). Using data for a total of 1.85 million workers from 2016 it is possible to see that 41% have qualifications at NVQ level 3 or above, 41% are apprentices or workers with qualifications at NVQ 2 or below, 8% have no qualifications and 10% are 'other' (Figure 1).

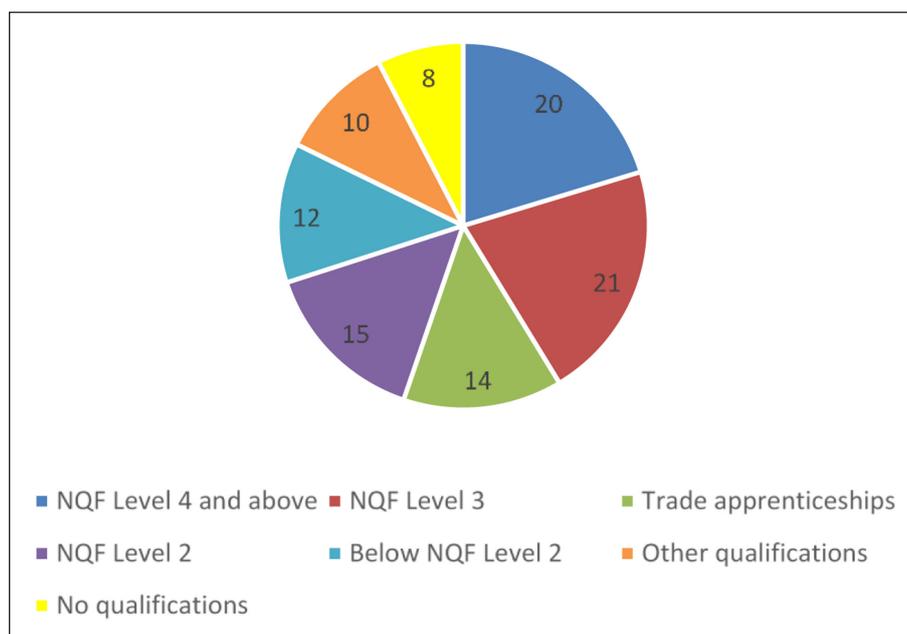


Figure 1: Percentage of qualifications across 1.85 million workers in construction, 2016. Source: ONS (2017).

It is likely (but not formally reported in these statistics) that the 41% at NVQ 3 or higher are either professionals (architects, engineers, consultants *etc.*) or craft trades at managerial/technician level; and that the 41% at NVQ 2 or below are manual trades. It is also likely (but not reported) that those with NVQ level 3 qualifications (and higher levels) work predominantly on larger scale projects, including new construction work of all kinds and also larger repair, maintenance and improvement (RMI) works. Those with qualifications at NVQ level 2 or below (including the unqualified 8%) may work as subcontractors on larger projects and small-scale new housing developments, but their main contribution to construction turnover is in delivering the bulk of RMI projects in the private housing sector.

The UK construction industry operates a training levy system through which in-scope firms have to pay a levy, which is administered by the Construction Industry Training Board (CITB). The CITB distributes the levy fund as grants for eligible workers (*i.e.* employees of in-scope firms) to attend approved courses. It is up to employers whether or not they seek to send workers on training courses under this system, with the exception of compulsory training on health and safety at work. The levy creates a financial incentive for firms to get something out of the system in return for the levy payment. But training involves releasing workers to attend the courses, which has a knock-on effect on labour availability on worksites. One of the effects of this is that employers are motivated to sign staff up for short courses of a few hours, rather than any longer time commitment.

4. Demand, supply and use of skills

Researchers in educational studies bring general insights, which have a bearing on discussions about the construction sector. Wolf (2004) argues that education and economic policy often target growth in training numbers because of an oversimplistic belief that more education leads to more economic growth, when in fact the thing that matters most is the quality of education and its relevance to economic and industrial strategy. Keep (2016) similarly argues that a policy focused solely on the supply of skills (*e.g.* new courses) is misguided:

Making optimal use of skills, preventing waste and attrition of skills due to mismatch or lack of use, and encouraging employers to demand higher levels of skill in stagnating regions or sectors are equally important elements of skills policies. (OECD 2011, cited in Keep 2016, 5)

Where education policy is not aligned with economic and industrial strategy in this way, the effect can be over-qualification just as much as under-qualification; and labour shortages may be felt in low-skills sectors of the economy just as much as in high-skills sectors (Wolf 2004; Payne & Keep 2011). The different possibilities can be summarised in terms of the match between the supply and demand for skills in any given sector (**Table 1**).

The UK market for VET is secondary to (or derived from) the market for work. In other words, a training course will only have a steady supply of students if there are meaningful job opportunities for them, and for which the training confers some kind of advantage. The sector is also very sensitive to wider economic cycles, with labour shortages in economic boom times followed by rapid drops in the numbers of jobs available during recessions (*e.g.* Dainty *et al.* 2007). The real issue is that training does not confer any significant advantage in the labour market. Trained and untrained workers are competing for the same jobs, working in the same conditions of low pay, low job security and low prestige. Without a real and sustained demand for trained workers, initiatives to improve the supply of skills will lead to over-qualification. Those who have undergone the training will have limited opportunities to use their newly acquired competence, *e.g.* in niche markets committed to quality outcomes. In reality, workers can see that the training is not necessary for winning work in the mainstream, and they simply do not sign up in big enough numbers to make the courses viable. This point needs to be underlined particularly in the Anglo-Saxon context, where there is a culture of overreliance on initiatives on the supply side of skills provision, without taking proper account of demand for skills (Payne & Keep 2011; Clarke, Gleeson, & Winch 2017). A third related dimension to the supply-demand question is that of skills use. Use of skills is important for achieving desired outcomes (*e.g.* good building performance, occupant satisfaction), and also for labour productivity. It is not a foregone outcome that the skills a worker has acquired will be put to effective use in the workplace, and in fact the mismatches can be significant between preparation for the workplace and the experience inside the workplace (Keep 2016). These three dimensions of skill–supply, demand and in-work use–need to be well aligned if VET is to make lasting change to activities in any workplace, including the various workplaces involved in construction.

The advantage of being skilled relates to labour market conditions in any given sector. That advantage may be competitive and discretionary (a trained job candidate might impress an employer at interview more than an untrained

Table 1: Matches and mismatches between sectoral supply and demand for skills.

	Low demand for skills	High demand for skills
High level of skill supply	Over-qualification (mismatch)	Professionalism (match)
Low level of skill supply	Low skills equilibrium (match)	Under-qualification (mismatch)

candidate); but it may instead be a required minimum standard for occupational competence in a regulated labour market, whereby only those with the requisite qualifications can be considered for job selection. There are plenty of occupations with minimum entry requirements and licensing (*e.g.* dentistry, motor mechanics). In the UK construction sector the picture is mixed: minimum standards apply to design professionals (architects, engineers), and to specialist contractors whose work carries immediate risks to health and safety (electricians, gas fitters); but for general builders and labourers no such standards apply.

Several authors have argued for some kind of feedback mechanism from one project to the next, embedded in a professional culture of learning and continuous improvement (Bordass & Leaman 2013; Aho 2013). This is based on the observation that design performance gaps are likely to persist when practitioners do not learn about the outcomes from one project before moving to the next. Feedback mechanisms between different stages of the construction process provide for the analysis and evaluation of outcomes (monitored energy performance, occupant satisfaction) in order to improve the whole construction process in future projects. Hartenberger, Lorenz, & Lütendorf (2013) argue that such a professional culture requires structural changes in the workplace and professional practice, not just changes to the education and training system. They make a specific proposal for the construction industry, borrowing two elements of custom and practice from the medical professions: an ethical statement of intent to give common purpose to built-environment professionals (akin to the Hippocratic Oath in medicine); and a closer alignment of practice with research and education (on the model of hospital consultants, who not only treat patients, but also engage in research and teaching). Proposals such as this open up the discussion on skills to include the wider structure and cultural context of work in a given sector.

5. An evaluation framework for low-carbon construction skills

In the previous section several arguments were made about the interdependency between demand, supply and use of skills, and these are important if one is to avoid the pitfall of focusing solely on new courses and other initiatives on the supply side. In this section the focus turns to a review of several important concepts from educational theory, which together can form the basis of an evaluation framework. This evaluation framework gives a fuller and more nuanced basis for discussions about learning in relation to the construction industry and zero-carbon targets. Three aspects of learning are considered in turn: types of learning, hierarchical orders of learning and domains of learning. Taken together they help to define what it means for a worker to be competent, and to identify the depth and breadth of learning in any given economic sector.

5.1 Competence and types of learning

Although the term 'skill' is widely used, its meaning is often vague and ill-defined. 'Skill' is used here to refer to embodied dexterity in the use of tools and materials, and is obviously relevant for practical occupations and manual, craft-based work. Knowledge, in contrast, is mental rather than physical, and relates to theory and general principles. In practice, knowledge and skills coexist and should be mutually reinforcing: the competent manipulation of tools and materials achieves a good result when it is based on applied knowledge of principles, leading to a reasoned evaluation of options and a final decision about what to do.

The meanings of these terms are also partly determined by language and culture. Therefore, Clarke, Winch, & Brockmann (2013) argue that the English (Anglo-Saxon) use of skill is rooted in practical task-oriented ability, while its German counterpart is rooted in a combination of practical and cognitive capacities associated with occupational identity. In each case, the term reflects cultural norms about the social organisation of work and employment: a focus on transient tasks and workers in the English-speaking world, compared with the German focus on a whole industry and the enduring occupations within it (Clarke & Herrmann 2007).

In French, knowledge is commonly classified into three constituent types: *savoir* ('know-what'), *savoir-faire* ('know-how') and *savoir-être* ('know-how-to-be'). The first two are close to English knowledge and skill, but the third has no easy translation. It encompasses concepts such as personal integrity, fair treatment of others, personal responsibility-taking and socially acceptable behaviour (Winterton, Delamare-Le Deist, & Stringfellow 2006; Brockmann *et al.* 2008). *Savoir-être* conveys a moral dimension of personal capability, which complements the cognitive and practical dimensions. It is rendered here by the term 'character', which seems less clumsy than 'know-how-to-be'. Character education refers to the development of responsibility, integrity and agency—what Kohlberg & Hersh (1977) call moral judgement: having regard for values of equality and justice, mediated by reciprocity in relationships.

While *savoir*, *savoir-faire* and *savoir-être* are personal attributes, it is useful to also distinguish 'competence' as a collection of attributes which are required for the pursuit of any given occupation, such as an architect or an electrician. Competence combines knowledge, skill and character. It can be thought of as a three-legged stool, each leg being as important as all the others (**Figure 2**).

Competence extends beyond the execution of a task or a project. It includes a worker's capacities to plan, control, coordinate and evaluate their own work (Clarke *et al.* 2013). An individual is competent when they show all the necessary attributes of their chosen occupation.



Figure 2: Competence as the combination of three different types of capability.

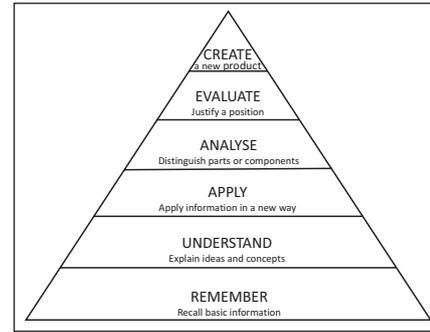


Figure 3: Revised Bloom's taxonomy of educational objectives. Source: Anderson *et al.* (2001).

5.2. Orders of learning

Each of the three types of learning described above can be analysed hierarchically into 'orders of learning'. An important common feature of these hierarchies is that every level subsumes all lower levels: it is not possible for a person to achieve one of the higher orders of learning without also being able to achieve the lower ones.

Turning first to *savoir* (know-what), Anderson *et al.* (2001) propose a revised version of Bloom's classic taxonomy of educational objectives (Bloom 1984), presented as a hierarchical pyramid (**Figure 3**).

Ferris & Aziz (2005) argue that Bloom's taxonomy is better developed for cognitive functions (thinking) than for psychomotor skills development (physical manipulation of tools and materials). This is clearly relevant for the practical, craft-based work of construction. These authors propose a taxonomy for the psychomotor domain (listed here in reverse order so that the highest-order skills are at the top):

7. Evaluation of outputs and planning means for improvement.
6. Planning of work operations.
5. Expert operation of tools.
4. Competent operation of tools.
3. Basic operation of tools.
2. Handling of tools and materials.
1. Recognition of tools and materials.

The distinction between basic/competent/expert operation of tools is not well theorised, so this seven-point scale could be reduced to six or even five points for a taxonomy of *savoir-faire*. It is also worth noting that Ferris and Aziz's highest level 'evaluation' is described only in terms of visual inspection of outputs, but that could and should be extended to include the use of monitoring tools and equipment in measuring invisible causes and effects of energy use in buildings (*e.g.* thermal imaging cameras, airtightness testing rigs).

For the third type of skill, *savoir-être*, Kohlberg & Hersh (1977) summarise research into moral educational development, identifying a hierarchy of six development stages or 'orientations'. These are framed in terms of what constitutes good behaviour, ranging from the lowest orientation (avoiding punishment) to the highest (reasoning from ethical principles) (**Table 2**).

Table 2: Stages of moral educational development.

Stage and orientation	Description
6. Universal ethical principle	Good behaviour is determined by individual conscience and choice, framed by ethical principles: comprehensiveness, universality and consistency
5. Social contract, legalistic	Good behaviour conforms with individual rights and standards, which are socially constructed (the social contract may change over time)
4. 'Law and order'	Good behaviour consists of doing one's duty, showing respect for authority and maintaining the social order for its own sake
3. Interpersonal concordance	Good behaviour is that which pleases or helps others. Behaviour is frequently judged by intention ('s/he means well')
2. Instrumental-relativist	Good actions are those that satisfy personal needs. Reciprocity (doing good for others) is pragmatic: 'I'll scratch your back if you scratch mine'
1. Punishment-obedience	Physical consequences determine whether an action is good or bad. Avoiding punishment and deferring to power are valued in their own right

Source: Adapted from Kohlberg & Hersh (1977).

Research in different academic disciplines has identified functional hierarchies of skill across all three types: *savoir* (knowledge), *savoir-faire* (skill) and *savoir-être* (character). Although these three hierarchies have been developed independently of each other and no formal equivalence should be inferred between the orders of skill, it is possible to tabulate all three for ease of reference (**Table 3**).

Table 3: Summary of skills hierarchies for knowledge, skill and character.

Order of skill	<i>Savoir</i> (knowledge)	<i>Savoir-faire</i> (skill)	<i>Savoir-être</i> (character)
6	Create	Improve	Ethical
5	Evaluate	Plan	Legalistic
4	Analyse	Operate (expert)	Normative
3	Apply	Operate (basic)	Relative
2	Understand	Handle	Instrumental
1	Remember	Recognise	Consequential

Sources: Adapted from Anderson *et al.* (2001), Ferris & Aziz (2005) and Kohlberg & Hersh (1977).

Each column in **Table 3** charts a progression from lower to higher orders of skill (reading from bottom to top). Lower orders are more reliant on sensory perception, simple repetition and effects felt at the level of the individual only. Moving to the higher orders introduces skills requiring the ability to perform new tasks, operate self-reflectively, communicate, plan, evaluate different options, create new ideas, and take account of the social and ethical context in which the individual operates.

5.3. Domains of learning

The third and final aspect of learning considered here is that of domain. A domain of learning reflects, and to a large extent reproduces, the broad culture of a sector in terms of the relationships and attitudes that exist within occupations or professions, and also between different occupations and professions.

Clarke *et al.* (2017) identify five different domains of learning:

- Task: the performance of actions to achieve a specific, short-term goal (*e.g.* plumbing in a sink).
- Project: the completion of multiple tasks to satisfy the client brief (*e.g.* fitting a bathroom).
- Job: the completion of multiple projects to satisfy an employer (including being self-employed).
- Occupation: the group identity of workers doing similar jobs (*e.g.* being a plumber).
- Industry: a broader group identity involving several occupations (*e.g.* being a member of the construction industry).

These five domains can be represented graphically showing each domain as being progressively broader than the one before (**Figure 4**).

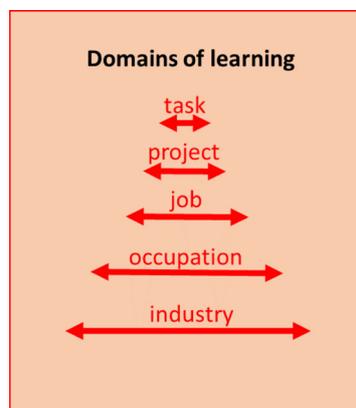


Figure 4: Domains of learning. Source: Adapted from Clarke, Gleeson, & Winch (2017).

Two studies comparing the UK with Germany give an indication of how domains of learning can affect the culture and quality of construction work. In the first of these, Clarke & Wall (2000) made a comparison between the UK and Germany between the 1970s and the late 1990s, showing how patterns of employment and educational qualifications changed in both countries (**Table 4**).

Table 4: Changes in the structure of employment and training in construction in Germany and the UK, 1970s–90s.

	Germany	UK
Labourers as part of the total construction workforce, 1974	33%	32%
Labourers as part of the total construction workforce, 1996	17.5%	35%
Change in labourers as part of the total construction workforce, 1974–96	–15.5%	3%
Change in youth trainee numbers, 1991–97	65%	–18%
Workforce self-employed, late 1990s	11%	>50%

Source: Clarke & Wall (2000).

Table 4 describes a period when the German construction sector increased its youth training numbers, reduced its relative number of unskilled labourers and consolidated employment to some extent into larger firms. In contrast, the UK reduced its youth training and became heavily reliant on self-employment and subcontracting, with the numbers of unskilled labourers rising slightly.

The second study summarised here analyses the characteristics of the UK's VET system, characterised by category differences between system operation in Britain and Germany (**Table 5**).

Table 5: Comparison of the production and training approaches to vocational education.

	Production approach (UK)	Training approach (Germany)
Loci of learning	Work based Trade or firm specific	Career based Occupation specific
Motives for learning	Individual choice	Occupational entry requirements
Modes of learning	On-the-job learning Short courses	Classroom learning, simulation, workplace application
Time spent in training	Shorter	Longer
Learning outcomes for worker	Able to perform tasks, satisfy short-term employer goals; lower levels of autonomy ^a	Able to pursue an occupation, adapt to future change; higher levels of autonomy
Level of qualifications	Lower (NVQ 2 or 3)	Higher (level 3 and above)
Possible to work unsupervised without qualifications?	Yes	No
Governance of vocational education and training (VET)	Industry led	Negotiated by employers, unions and educationalists

Note: Here 'autonomy' refers to a worker's capacity to make good unsupervised decisions, using higher order skills. It does not mean 'freedom from supervision', even though that meaning is common in the context of UK construction management, where fragmentation, self-employment and subcontracting predominate.

Source: Adapted from Clarke *et al.* (2017).

In the 'production' approach (typified by the UK), the overarching characterisation is of an employer-led training system adapted to predominantly short-term perceptions of the need to get certain tasks completed. Time spent on training is viewed as time away from gainful employment, so very short courses are preferred (single day or shorter). In contrast, the 'training' approach (typified by Germany) aims to equip workers for a working life in a given industry, with longer term priorities based on the need to maintain a competent workforce into the future, even though the nature and quantity of future work is unknown. Time spent on training is viewed as a minimum requirement for developing a competent workforce, which underpins labour and wider economic productivity. The 'production' approach is more attuned to neoliberal market philosophy founded on individual choice, while the 'training' approach is more regulated and codified, based on a negotiated social contract between employers, professional bodies, trades unions and industry experts. The 'training' approach results in 'occupational labour markets', which has several features of divergence from the Anglo-Saxon 'production' approach. In occupational labour markets, market entry is regulated (minimum qualifications are required). The longer time spent in formal education brings important benefits: it allows for the development of underpinning theoretical knowledge; it allows for a broad industry foundation to be taught before occupational specialisation, and it enables higher order learning to be achieved.

In summary, this section has reviewed literature from educational theory and construction management, which have a bearing on the future of low-carbon construction. Three sets of considerations are proposed for an evaluation

framework of learning. First, there is the concept of competence, which combines the three types of learning (theoretical knowledge, practical skill and character education). Second, the learning for each of these different types can be organised hierarchically, with a higher order of learning incorporating all of the lower levels, as well as adding something new and more advanced. Finally, several different domains of learning can be usefully identified, from the very narrow and specific domain of an individual task through to the very broad and general domain of an entire industry. A composite evaluation framework can combine types of learning (**Figure 2**), orders of learning (**Figure 3**) and domains of learning (**Figure 4**).

5.4. Types, orders and domains of learning used by pioneers low-carbon retrofit

In this section the conceptual framework of learning described in the previous section is used as a lens through which to analyse previous studies of retrofit with a focus on the pioneering innovators who have found ways to achieve good-quality outcomes. The evidence base for this analysis is not very large because retrofit itself is not a mainstream activity, and also because the experiences and perspectives of on-site construction workers remain under-researched.

Fawcett & Killip (2014) conducted qualitative research with pioneers of housing retrofit among owner-occupiers, finding a diversity of strategies and approaches in evidence. Two characteristics emerged that were common across the 'superhomer' sample (*i.e.* owner-occupiers who had achieved ambitious retrofits in their own homes): a strong value-driven motivation to 'do one's bit' to mitigate climate change; and a personal commitment to education (informal or formal) in order to make principled and pragmatic design decisions. These decisions were often made in the face of contradictory and plain wrong advice from installers and others involved in the project. In terms of types and orders of learning, the sample of superhomers showed high levels of theoretical knowledge and high levels of character education. Indeed, for several of them the experience of negotiation with construction firms was stressful and time-consuming because those firms did not have the necessary technical knowledge nor the value-led commitment to climate mitigation of the superhomers themselves. In some cases this group also had high levels of practical skill in one or more craft trades, or had friends and family members with relevant skills, and who they trusted to do a good-quality job. The domains of learning in evidence among the superhomers was largely limited to the domain of a single project, which is consistent with the needs of owner occupiers carrying out retrofit works to their own homes. They cared about the quality of the project without needing to take responsibility for the broader quality of the industry.

Although it was not an explicit aim of the study, this research highlighted the fact that these projects were hard to achieve because of the low orders of learning in the mainstream in terms of theoretical knowledge and character education. Killip, Owen, & Topouzi (2020) found a similar picture from a different perspective: that there is a small group of niche 'green' merchants and manufacturers who operate as brokers of learning and experimentation in the construction supply chain, typically serving knowledgeable clients with strong green values.

Killip, Fawcett, & Janda (2014) found that several unusual and innovative business practices contributed to the success of an award-winning retrofit project on 36 homes owned by an English housing association. These practices included:

- the use of a directly employed workforce (direct labour organisation);
- a financial incentive scheme which rewarded early completion of the project, not the completion of individual tasks;
- an effective site management team;
- multi-skilling that cut across conventional trade roles (*e.g.* carpenters helping plasterers); and
- involvement of the on-site workforce in learning from early mistakes in order to improve later productivity and outcomes.

In this case, there was a formal management structure between those holding technical and managerial knowledge (the management team) and those with practical skill (the on-site labour force). Even so, two unusual factors led to the workforce being engaged with higher domains of learning than might normally be the case. The financial incentive for project completion helped redirect attention to the project domain, rather than individual tasks; and the fact of working in a direct labour organisation meant that the project team knew each other well, and had some commitment to their work as a job with regular colleagues, not as a one-off project or a subcontracted task. Another noteworthy innovation was the involvement of the on-site construction team in improving the design and construction process from one phase to the next. This was shown, for example, when an existing staircase was taken out and refitted, but the installation of insulation materials had changed the relative floor heights and the staircase would no longer go in. It required both theoretical knowledge and practical skill to create a solution that was practically buildable.

Moving on from the experiences of single projects and single firms, some studies have also investigated the establishment of cooperatives and consortia, designed to deliver multiple projects over longer timeframes. Killip *et al.* (2014) describe a locally based cooperative of building firms in France, in which the key innovation is the cooperative business model. Participation in the coop enables members to promote opportunities for ambitious retrofit projects, supported not only by the network of other firms but also by centralised 'back office' functions for technical support, marketing and administration. Firms undergo training before they can join. Good workmanship and professional

behaviour are reviewed collectively by coop members—a form of peer-to-peer quality assurance. In this cooperative structure types and domains of learning are associated with different elements of the business model. Orders of learning are distributed strategically among the workforce, with the higher orders being held centrally and accessed on demand by project teams. The responsibility of project teams to make use of these centralised functions requires higher levels of character education among the on-site workforce. For the business model to be effective the distribution of capabilities needs to be integrated and coherent.

Mlecnik *et al.* (2017) found several different possible configurations of consortia for retrofit in different European countries. It took an investment of time from all project partners to develop mutual trust and fair ways of sharing risks and rewards. This requires higher orders of character education, matched by clear contractual terms. The character education is important but is unlikely to be sufficient on its own: changes are also needed in business practices, including the social and legal organisation of project teams.

6. Discussion

This paper has described the economic and social context of the UK construction sector as being in a low skills equilibrium, with a vocational training system based on voluntarism and short courses. Government statistics show that something like half of the labour force has the lowest level of training (NVQ 2) or no training at all. The fragmentation of work roles and responsibilities in the UK is exacerbated by the culture of training defined by conventional job roles. There is no general foundation training in the use and performance of buildings, nor in the processes and practices of construction taken as a whole. For example, a plasterer learns how to mix and apply plaster and fit plaster-board, but does not have that job role contextualised in relation to the final built product, the full processes of construction or the effects that plastering practices may have (good or bad) on building performance, including energy performance.

Debates about skills training focus too narrowly on the supply of skills, not on demand and use in the workplace. When the supply and demand for skills are not well matched, the outcome is over- or under-qualification, neither of which represents a well-functioning market. The shift required is from the current low skills equilibrium to a state of much greater professionalism, in which learning is in high demand and high supply.

Nor is 'skill' a sufficiently broad term to capture the types of learning required. Instead, occupational competence should be the goal, combining theoretical knowledge, practical skill, and moral character. Higher orders of learning are required for all three, compared with the current situation where theoretical knowledge and character education are both noticeably lacking. The ability to manipulate tools and materials is essential in construction work, but it needs to be matched by the ability to analyse and create solutions based on sound theoretical principles, and by a common shared responsibility for good-quality outcomes.

The achievement of low or net-zero carbon in building projects requires integrated approaches to design and execution, which are not compatible with a narrow scope of learning, focused only on individual tasks. The integration of multiple tasks requires a project-level scope of learning; and the delivery of multiple projects over time requires a broader scope again. For net zero to be achieved means that the entire industry and all the occupations within it need to be oriented at all times towards good-quality outcomes.

Business practices that include feedback mechanisms have been found on projects, within firms and in broader networks. Learning on projects is important to evaluate innovative materials and processes, adapting the process through iterative rounds of action and reflection among project teams. For innovative practices and processes to persist beyond a 'one-off' there needs to be a mechanism by which firms can embed the learning from one project to the next. New business models have sought to normalise some of these processes, *e.g.* through their customer offer (a high-quality service) or their own internal governance (*e.g.* cooperatives with structures in place for peer-to-peer quality control). These examples show that learning is not only about building physics and the successful assembly of materials on projects, but also about processes and practices for business management and strategy development. There are several modes of learning in operation at the same time. Business model innovations are needed to distribute learning effectively in a complex-product industry such as construction.

This discussion also helps to situate the question of educational reform in a wider context. At all stages—projects, firms, networks and business models—educational reforms need to co-evolve with reforms in the conduct of business, employment and market opportunities. What, then, should these wider reforms consist of? It is hard to escape the conclusion that profound labour market reform is required in the construction industry if the UK is to get anywhere close to net zero. A licence to trade would enable the government to regulate entry into the labour market, by applying occupational standards as minimum requirements. Whether such standards should apply at the level of every individual worker, or at the level of site supervisors or company directors is the kind of detailed policy design decision that needs to be got right. It is beyond the scope of this paper to propose such reforms in detail. Complementary reforms would be needed to stimulate demand for this new level of competence in the workforce. Regulation of building performance outcomes (not just design intent) should be the goal here. Once again, the success of any such policy will be largely dependent on the detail of policy design.

In very broad terms, the interdependence between VET and a future regulated labour market could comprise three elements: training, accreditation, and compliance. The demand for training would come from the need to be accredited, because it would not be possible to work in the sector without accreditation. Properly resourced compliance checks

would be needed to ensure that the accredited workforce was delivering sufficiently good quality in its projects. The regime of compliance checking would not only enforce regulations, but also serve as an early warning system for any significant problems with industry practices and processes, which could then inform the future development of training. In this way the three elements of training, accreditation and compliance can be viewed as stages in a cycle of quality assurance and continuous improvement.

7. Conclusions

The current state of learning in the construction sector is hindering the achievement of targets for low or zero carbon. A narrow focus on skills supply simply perpetuates the problem because consideration needs to be given to the demand and use of knowledge and skills. This means there is a pressing need to better integrate energy and climate policy with economic and educational policy. Any attempt to align these multiple policy domains will inevitably be complex and messy.

The scale and breadth of the reform agenda proposed here is enormous. It would inevitably be contested, given that change is always uncertain, and there are vested interests for whom the current system works well enough, in the sense that it provides a means of making a living in an existing market, which is at least in a state of equilibrium. A major reform programme seems inevitably high risk. Nor is it realistically something that could be implemented quickly, notwithstanding that climate policy emphasises the need for rapid change. However, any even remotely plausible alternatives also involve high levels of risk and uncertainty. If the construction sector in the UK remains in its low skills equilibrium, then the assumptions made in policy scenarios about the large-scale deployment of energy efficiency retrofits and low-carbon technologies need to be massively reduced. This would have enormous consequences for technical and policy options, *e.g.* on the supply side. It may be that the option of professionalising the construction sector carries lower risks and greater benefits than the alternatives, but the scale of the task should not be underestimated. A strategic policy choice needs to be made and stuck to. If that choice relies on the construction industry as agents of change in a net-zero transition, then the pressing need is to make a start soon on deep educational and economic reforms, and to do the job as well as possible.

Note

- ¹ The definition of false self-employment is based on four characteristics of the relationship between worker and client/employer: control of workflow; the integration of workers in organisational policies and benefits; the economic reality of autonomous working and tax responsibilities; and the mutuality of obligation in terms of current and future work.

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Competing interests

The author has no competing interests to declare.

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