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Architects as educators in owner-occupied retrofit: Situated learning in design interactions

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ABSTRACT

Retrofitting owner-occupied housing is critical to achieving decarbonisation targets, yet uptake remains limited. While social approaches emphasise building experts' role in engaging households with retrofit, the interactional agency of architects remains insufficiently specified within energy research. This study examines how architects can enable owner-occupiers to engage with low-carbon retrofit within wider home improvement projects. A micro-ethnographic study combined six observations of early design interactions with fifteen in-depth interviews with architects and owner-occupiers in England and Wales. Participating architects worked in purposively selected micro-practices committed to low-carbon design. Drawing on practice theory, the study conceptualised retrofit as emerging within a nexus of practices. It introduced learning pathways to trace how competences developed through design interactions connect with meanings, material arrangements and further competences in owner-occupiers' practices. These pathways informed reflexive thematic analysis.

The most prominent pathway concerned the reconfiguration of worth, consisting of jointly reconsidering what constituted worthwhile improvements within particular projects, especially where retrofit was not initially planned. Developing retrofit competences and managing material risks supported this process, helping owner-occupiers evaluate low-carbon options in relation to their aspirations and existing homes. The findings suggest that architects can bring latent retrofit opportunities into wider home improvement projects by addressing unresolved questions of value and priority. The study characterises architects' agency as relational education, enacted through connecting goals, challenging assumptions and balancing competing priorities. It identifies early briefing as an opportunity for incorporating retrofit and suggests that policy and professional frameworks could provide support for reflexive design dialogue through extended, iterative briefing.

1. Introduction

Retrofitting existing homes is widely recognised as essential to achieving climate mitigation targets [1,2], yet progress in upgrading the housing stock remains slow across many developed countries [3], including the UK [4]. In the UK, the owner-occupied sector has proven particularly resistant to change, despite accounting for the majority of dwellings and a substantial share of domestic energy demand [5,6]. Policy explanations for this resistance have increasingly focused on educational deficits, assuming that limited retrofit uptake reflects a lack of awareness among owner-occupiers [7–9]. However, a growing body of research shows that many owner-occupiers remain disengaged from retrofit even when they are well informed, financially capable, and

environmentally concerned [10–12].

These findings reveal the limits of approaches that treat retrofit decisions as primarily cognitive or attitudinal and point to the need for alternative conceptualisations of learning and engagement. In response, energy research has increasingly drawn on practice-based perspectives that locate learning within everyday activities rather than solely within individual cognition [13–16]. The focus on these situated processes foregrounds the role of building professionals in shaping how retrofit becomes intelligible and actionable for owner-occupiers [17,18].

Among these professionals, architects occupy a distinctive yet under-examined position because of their close relationship with clients and early involvement in projects [19,20]. However, existing work has tended to conceptualise professional influence at structural or network

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levels [21], leaving the interpersonal enactment of agency comparatively underexplored. Consequently, architects' efforts to advocate for sustainability have been described as 'quiet' [22], 'invisible' [23], and 'undertheorised' [24]. This paper addresses this gap by examining architects as educators in owner-occupied low-carbon retrofit.

This research does not present architects as representative of all forms of professional engagement in retrofit. In social housing or granted delivery routes, household engagement can be distributed among different roles such as retrofit adviser alongside programme-based staff or local authorities [25,26]. Previous studies have also shown that builders, installers and other professionals can influence understanding, technology choices and retrofit decisions [27–29]. By contrast, this study focuses on architects working in privately commissioned home improvement projects, where they are often involved during briefing and concept design, when spatial, aesthetic and domestic aspirations remain open to negotiation. Hence, this research examines a distinctive design-led route into retrofit among owner-occupiers able to commission architectural services, including projects in which retrofit was not part of the initial brief. Previous studies show that such households do not typically initiate retrofit as a discrete project, but they do invest in extending, reconfiguring and renovating their homes, and this home improvement activity has been identified as a latent but largely unexploited entry point for low-carbon measures [30–32]. The significance of this design-led route therefore lies in architects' involvement during briefing and concept design, when the scope of work is still being defined and retrofit can potentially be incorporated.

The current study conceptualises learning as emerging through the reconfiguration of practice elements. Drawing on practice theory [33], it investigates how architects' design interactions enable owner-occupiers' engagement with low-carbon material arrangements, and how competences formed in these interactions circulate across elements of owner-occupiers' practices, including materials, competences and meanings.

Drawing on observations of architect–owner-occupier interactions during early design stages (RIBA Stages 1 to 3), alongside interviews with both participant groups, this paper investigates how architects shape owner-occupiers' engagement with low-carbon retrofit. Building on research that recognises the broader social and relational dimensions of architects' engagement with retrofit [34], the study examines how retrofit becomes meaningful and actionable through situated design interactions embedded within broader home improvement projects. Accordingly, this paper makes four interrelated contributions to understanding architects' educative agency in owner-occupied retrofit.

First, it extends research on architect–client negotiation by specifying how design interactions bring low-carbon retrofit into wider home improvement projects (see Section 6.1). Second, the analysis shows how design exchanges can change the criteria by which owner-occupiers judge what constitutes a worthwhile improvement to their homes. The conceptual contribution is to locate learning in the reworking of project purposes and possibilities alongside the development of technical knowledge (see Section 6.2). Third, it develops an account of architects' agency by specifying how professional knowledge and owner-occupiers' experience are brought into relation through design exchanges. This provides an account of the educative practices through which architects' influence operates within the nexus of practices (see Section 6.3). Fourth, it derives implications for briefing, professional development and retrofit delivery from this account of learning. It provides a basis for considering how professional frameworks can recognise and support these activities (see Section 6.4).

These contributions highlight the importance of inclusive, participatory approaches that clarify the role and implications of design expertise in accelerating retrofit. The paper proceeds by positioning owner-occupied retrofit within debates on learning and practice, before outlining the theoretical framework and qualitative approach. It then presents empirical findings on how design interactions shape learning pathways to retrofit. This is followed by a discussion of implications for retrofit policy, architectural practice, and conceptualisations of

professional agency in retrofit.

2. Background

Domestic buildings in the UK are responsible for 69.8% of building-related energy use and 58.7% of building-related emissions [6]. Owner-occupied homes account for 63% of dwellings in the UK housing stock [35] and persistently represent the largest share of inefficient properties [2,4]. Meeting decarbonisation goals therefore requires upgrading the energy performance of the existing owner-occupied housing stock at scale [5]. However, direct regulation of owner-occupiers has conventionally been avoided, reflecting the politically sensitive nature of intervention in the private home and households' lower acceptance of imposed energy-efficiency measures [8,36,37].

Recent years have seen tightening of Building Regulations Part L standards. Nevertheless, reports indicate that stricter environmental legislation has not resulted in sufficient progress towards achieving the 2050 net-zero target [9,38]. Financial incentives have been introduced as a more flexible mechanism to encourage retrofit [39], yet these too have struggled to stimulate large-scale investment in residential retrofit in the UK [40]. These limitations have increasingly shifted policy emphasis towards educational interventions.

Information-deficit and behaviour-change models have dominated educational efforts to influence household energy decisions [7,41,42]. Information-deficit models propose a linear relationship between increasing awareness and better action. Nevertheless, previous studies found that information-deficit models did not lead to owner-occupiers' engagement with retrofit [10,43]. Moreover, recent research indicates that difficulties surrounding retrofit information concern not only its availability but also its contextual relevance, mode of communication, and the trust placed in those providing it [44].

Behaviour-change models emphasise tailored information intended to make communication effective across different behavioural contexts [7,45]. These approaches are referred to as behaviour change or the ABC model, wherein changes in behaviour (B) result from an interaction between external contextual factors (C) and internal attitude variables (A) [45]. However, studies have noted the short-lived influence of behavioural models and highlighted that attitude-oriented interventions may have limited or temporary effects where established habits and wider contextual conditions remain unchanged [46,47]. Ethical critiques have also questioned behaviour-change approaches where desired outcomes are externally defined and participants have limited autonomy or meaningful involvement in the processes of change [48].

Within energy research, social approaches have emerged as an alternative to the predominantly individualistic understanding associated with information-deficit and behaviour-change models [14]. These social approaches examine how energy efficiency becomes embedded in everyday life [13,14,49–52]. From this perspective, retrofit and energy-efficient choices emerge in response 'to changing opportunities and practices that sometimes favour energy efficiency and sometimes do not' [53]. Learning has similarly been located within intensive interactions between homeowners and other actors who hold different understandings of the challenges, responsibilities, and potential solutions associated with energy retrofitting [54]. Janda and Topouzi [15] place such interactions within the practical settings in which people confront the challenges of adopting low-carbon measures, arguing that building performance and the multiple stories surrounding it can provide situated learning opportunities.

Recent research has further developed relational and socially situated understandings of domestic retrofit. Studies have shown that households do not act as isolated decision-makers but engage with retrofit through relationships, life circumstances, existing home improvement activities, and networks of advice and provision [30,55–58]. These findings are consistent with research linking experts' influence to their capacity to involve homeowners in retrofit [59,60]. Yet, while the importance of professional engagement is increasingly

recognised, previous research has highlighted the gap in understanding professional influence in retrofit [60,61]. Research suggests that mismatches between actors' agency and capacity during planning and design can hinder the integration of energy-efficiency measures into wider home improvement projects [62]. Architects warrant particular attention here because of their early involvement in design, yet their influence within these interactions remains under-examined.

2.1. Architects' role

Owner-occupiers encounter retrofit through several professional routes, including architectural services. In grant-funded and programme-led delivery in the UK, household engagement could be organised around the defined roles of PAS 2035, including Retrofit Advisor, Assessor, Coordinator, Designer and Evaluator [25,26]. Each of these roles involves engagement with owner-occupiers at a different point in the retrofit journey, but presupposes that they have already decided to retrofit or that retrofit is being delivered to them. Under PAS 2035, an architect may be appointed as Retrofit Designer or Coordinator. However, home improvement projects, such as extensions, reconfigurations or renovations, provide an important point of contact between architects and owner-occupiers. It is in these commissions that architects are engaged during briefing and concept design, before the scope of works is fixed.

This position is significant for the retrofit challenge for two reasons. First, as discussed earlier (see Section 2), the owner-occupied segment, particularly households able to contribute to the cost of retrofit, is precisely the part of the housing stock that direct regulation has avoided and financial incentives have failed to move. Consequently, programme-led retrofit delivery has had limited reach in this sector. Second, routine renovation and extension work has been identified as a latent but largely unexploited entry point for low-carbon measures [30–32]. Programme-led routes that begin with an existing intention to retrofit may therefore overlook these opportunities. The design-led route examined here is therefore not a marginal case of retrofit delivery but a distinct route into retrofit, one through which low-carbon measures may be introduced to owner-occupiers who did not set out to adopt them.

Previous studies have identified a related capacity within architectural practice, suggesting that interactions between architects and householders constitute sites of learning [63]. Research indicates that architects often establish direct and complex relationships with clients, engaging in design dialogue at stages where decisions remain fluid and the trajectory of building work can still be influenced through reasoning [19,64–66]. Recent research on architectural interaction provides further insight into the interpersonal processes through which professional influence is enacted, conceptualising architectural engagement as a process through which project possibilities are interpreted [67] and value is actively constituted [68]. These adjustments are particularly significant because routine renovation, repair and extension projects can contain latent opportunities for incorporating low-carbon measures [30,31], and architects are considered well positioned to identify and mobilise such opportunities [34]. Recent research has also emphasised the role of architects in mediating between households' situated knowledge and technical requirements as well as regulatory constraints [59].

Furthermore, previous research has demonstrated that architects' engagement with domestic energy is shaped by professional identity, client relationships and judgement about professional responsibility [69]. Professional frameworks have increasingly recognised architects' responsibilities within broader shifts towards sustainability and social responsibility. The International Union of Architects (UIA) [70] has described this transition as a reorientation of the profession to address the intertwined challenges of the climate crisis and rapid technological change. In the UK, there are growing calls to integrate sustainability and retrofit within professional standards [71,72]. Yet, despite acknowledgement of their strategic position, the ways architects exert influence

in everyday interactions remain underexplored.

Previous studies noted that architects in micro-enterprises remain underrepresented in environmentally sustainable design despite their direct influence on clients in designing homes [73]. Likewise, architectural scholarship has described architects' agency as 'quiet' and 'invisible,' particularly where social and sustainability objectives are embedded within routine design practice [22,23,74]. This limited visibility has also been linked to the absence of conceptual frameworks capable of capturing the social objectives and sustainable practices enacted through design [24,75]. This study therefore does not claim that architect–client negotiation is itself novel. Instead, it focuses specifically on how architects' agency is enacted through interactions with owner-occupiers in micro-sized architectural practices, and how these early design interactions shape the relevance of low-carbon measures within wider home improvement projects. The following section develops a practice-theoretical approach for examining this interactional form of agency.

3. Theoretical approach

Existing research has conceptualised professional influence primarily through intermediary and middle-actor frameworks. These approaches depict professionals as actors operating within networks or occupying middle layers of social structures, enabling them to transfer and translate information. Architects, for example, have been described as middle actors in the domestic sector [76] or as 'neutral networkers' without a specific agenda in innovation processes [77], with relatively minor influence on zero-carbon innovation [78].

While this literature has been valuable in highlighting structural positioning, it leaves limited room for analysing how influence is enacted in practice and through which mechanisms it operates [60,61]. Moreover, such systemic perspectives risk misrepresenting professionals whose agency is exercised primarily in interpersonal and relational contexts [21]. Responding to recent calls to examine agency through concrete actions and transactions rather than treating it as a fixed attribute of actors [79,80], this study focuses on how architects' agency is enacted through design interactions with owner-occupiers. The research takes practices as its central unit of analysis, thereby moving beyond system-level explanations and linking agency to the shaping of action in the social world [81,82].

Although no single definition of practice theory exists [83], scholars share a commitment to understanding social phenomena as organised constellations of sayings and doings distributed across sites of social life [84]. This concept is further explored in the notion of a nexus of practices, which conceptualises social life as constituted through bundles of intersecting practices unfolding in specific time–space contexts. This emphasis on interconnection supports analysis of social change across wider networks of practices, an aspect often underdeveloped in narrower formulations of practice theory [85]. Previous studies have employed nexus thinking to examine changes in routinised domestic energy practices, highlighting how new forms of energy knowledge emerge through practice [12,16,52]. Its application in empirical research has also begun to illuminate the potential role of architects in developing retrofit competences through negotiated trade-offs in real-world projects [34].

In relation to learning, a nexus perspective locates learning within the interconnections through which practices and their participants shape one another, rather than solely within individual learners. Within nexus thinking, learning is understood as a process through which elements that make action sensible in one practice are reconfigured through engagement with other practices [86]. Kemmis et al. [87] develop this understanding by describing learning as being 'stirred in' or 'initiated into' practices. Kemmis [88] further locates learning in changing engagement arising when participants in intersecting practices open or redirect possibilities for one another's action. Architect–owner-occupier interactions can therefore be treated as educative not because

architects occupy a formal teaching role, but because design engagement can alter owner-occupiers' capacity to interpret, evaluate, and participate in retrofit decisions. Home improvement projects are accordingly treated as nexuses in which architectural, domestic and retrofit-related practices intersect.

3.1. Theoretical framework

Previous studies have theorised the movement of knowledge at the intersection of practices, arguing that knowledge moving between practices is not simply transferred unchanged. Rather, it becomes relevant through recontextualisation and through the connections established with the elements of the receiving practice [33,86,89]. Applied to the present study, this directs attention to how knowledge articulated through design interactions becomes connected to the elements of owner-occupiers' practices. Examining these interdependencies empirically, however, requires a more tractable analytical vocabulary. This study therefore draws on the practice model developed by Shove and colleagues [33], which conceptualises practices as configurations of materials, competences, and meanings.

To operationalise this account, the study introduces learning pathways as an author-developed analytical approach. Drawing on Shove et al.'s [33] model, the pathways trace how competences articulated and co-developed through design interactions become connected to changes in the material arrangements, meanings and further competences of owner-occupiers' practices. Competence forms the analytical starting point because the observed design interactions involve the articulation and negotiation of professional and experiential knowledge. The educational influence of design exchanges is therefore examined through the movement of shared competences towards material arrangements (C → MA), meanings (C → ME), and further competences (C → C) (Table 1).

Because the study focuses on how owner-occupiers are initiated into retrofit, the circulation of co-created competences is analysed in relation to the elements of owner-occupiers' practices. Accordingly, learning pathways enable a fine-grained analysis of learning in domestic retrofit, moving beyond the transmission of information to examine the reconfiguration of material arrangements, the reshaping of meanings, and the redistribution of competences across practices. Thus, while the nexus perspective offers the broader ontological grounding, Shove et al. [33] provide the empirical vocabulary through which changes within owner-occupiers' practices are traced.

4. Research methods

A qualitative approach was adopted to examine architects' situated interactions with owner-occupiers and profession-specific practices in depth [90]. The research design drew on micro-ethnography. Micro-ethnography, or ethnographic microanalysis, involves intensive focus on specific aspects of social life over shorter timeframes than traditional ethnography [91]. In this study, this approach facilitated the examination of multiple instances in which architects engaged with owner-occupiers across a range of projects. This is consistent with previous

Table 1
Learning Pathways. Source: Authors.

Learning Pathway	Description
Competences to Material Arrangements of owner-occupiers' practices (C → MA)	Maps changes in owner-occupiers' engagement with the physical aspects of their homes.
Competences to Meanings of owner-occupiers' practices (C → ME)	Maps changes in aims, goals, and aspirations that drive owner-occupiers' engagement in projects.
Competences to Competences of owner-occupiers' practices (C → C)	Maps changes in the skills and knowledge that enable owner-occupiers to engage more effectively with retrofit.

studies that advocate the use of micro-ethnography to move across shared time-space contexts and explore how practices are interconnected [82,92].

4.1. Recruitment

This research employed purposive sampling to identify cases that could provide rich insight into how architects shape owner-occupiers' engagement with low-carbon retrofit through design interactions. Accordingly, recruitment focused on architects with explicit ambitions for low-carbon design and experience in domestic retrofit, where practices of negotiation, learning, and advocacy were expected to be particularly pronounced. Registered architects were selected through climate-focused professional networks, with an emphasis on housing retrofit experience and explicit energy-efficiency ambitions (see Table 2). Architects were invited to be observed during meetings with clients as a first preference. Interviews were offered where observation was not feasible.

Owner-occupiers were recruited through referrals from participating architects. Given that energy-efficiency discussions occur across a wide range of domestic project types [30–32], home improvement was adopted as the overarching scope. This framing allowed inclusion of diverse types of interventions while maintaining focus on existing homes. Selection criteria for architects and owner-occupiers are summarised in Table 3.

In total, 154 practices (representing 199 architects across Scotland, England, and Wales) were contacted. Sixteen architects from twelve firms and thirteen owner-occupiers across nine domestic projects ultimately participated. All participating architects worked in practices with fewer than ten employees, a segment of the profession in which private housing represents the largest source of revenue [93]. The nine projects differed in how retrofit entered the design process. In five projects, retrofit was planned from the outset, whereas in four it emerged during the development of broader home improvement proposals. These are referred to as planned and emergent retrofit projects, respectively. Data collection comprised six observations of architect-owner-occupier interactions and fifteen in-depth interviews across both groups. Participants are identified using anonymised codes. AR denotes an architect and OW denotes an owner-occupier. Anonymised participant, project and data-collection metadata are provided in Appendix A (Table A.1).

4.2. Data collection and analysis

Observations and interviews were used to explore situated practices of architects as the unit of analysis. Observations focused on early design-stage interactions (RIBA Stages 1 to 3). These sessions enabled

Table 2
Professional Networks for Recruitment. Source: Authors.

Professional Network	Purpose
Association for Environment Conscious Building (AECB)	'...To deploy environmentally responsible building practices.'
UK Architects Declare Climate and Biodiversity Emergency	'... network of architectural practices committed to addressing the climate and biodiversity emergency.'
UK Green Building Council (UKGBC)	'... aims to radically transform the way that the built environment in the UK is planned, designed, constructed, maintained, and operated.'
Architects Climate Action Network (ACAN!)	'... network of individuals within architecture and related built environment professions taking action to address the twin crises of climate and ecological breakdown.'
RIBA 2030 Climate Challenge Signatories	'... help architects meet net zero (or better) whole life carbon for new and retrofitted buildings by 2030.'

Table 3
Participant Selection Criteria. Source: Authors.

Participant Group	Inclusion Criteria
Architects	UK-registered architects with domestic-retrofit experience, explicit low-carbon ambitions and direct engagement with owner-occupier clients.
Owner-Occupiers	Owners of existing homes referred by participating architects and involved in relevant design interactions concerning home improvement and potential low-carbon measures.

close attention to how learning unfolded through dialogue, drawings, material references, and negotiation of project goals in real time. Interviews with architects and owner-occupiers explored participants' reflections on retrofit decisions, design processes, and experiences of learning. Interviews complemented observations by providing insight into how participants interpreted interactions over time and how learning extended beyond specific encounters. Combining observations and interviews aligns with recommendations to examine educative practices in ways that reveal aspects of practice formation and interconnection that participants may find difficult to articulate [94].

Data collection took place between March 2022 and February 2023. All interviews and observations were audio-recorded and transcribed verbatim. Full ethical approval was obtained from the Research Ethics Committee, School of Architecture and Built Environment, Northumbria University (41759).

The research adopts reflexive thematic analysis (reflexive TA) [95]. Reflexive TA allows theoretical assumptions to function as interpretative lenses without predetermining the core topics of analysis [96]. Accordingly, it accommodates the study's practice-theoretical orientation towards the co-production of knowledge while remaining open to diverse forms of knowing emerging from the data.

Reflexive TA uses systematic coding to focus on data segments relevant to the research questions and guiding theories [97]. In this study, coding focused on identifying instances in which architects and owner-occupiers jointly engaged with design propositions, materials, or narratives in ways that reshaped participation in practices. These instances were analysed through the lens of learning pathways, conceptualised as the circulation of competences towards meanings, materials, or further competences within owner-occupiers' practices (see Table 1). Related codes were then brought together into themes representing recurring forms of educational action. Table 4 summarises the coding process.

The first author coded and analysed the complete dataset using NVivo 14, a computer-assisted qualitative data analysis software (CAQDAS) package. Because reflexive TA treats researcher interpretation as an analytical resource, inter-coder reliability was not calculated. Instead, consistent with reflexive TA [95,96], analytical quality was supported through recursive engagement with the complete dataset, iterative refinement of codes and themes, comparison between observational and interview evidence, inclusion of architects' and owner-occupiers' perspectives, fieldwork and analytical memos, and reflexive consideration of the researcher's architectural background. Themes and interpretations were also reviewed and agreed upon with the co-authors.

Table 4
Analysis Steps. Source: Authors.

Step	Description
Episode Identification	Identification of episodes demonstrating the circulation of co-created retrofit competences into owner-occupiers' practices.
Structuring Codes	Using a priori codes to identify learning pathways (C → MA, C → ME, C → C).
Action Coding Analysis	Detailed review and coding of episodes to capture competence adaptations.
Theme Generation	Aggregation of action codes to form themes addressing architects' educational actions.

5. Results

The three data sources provided complementary forms of evidence. Observations captured how learning developed turn by turn through dialogue, drawings, design alternatives, reports, and material samples. Architect interviews provided retrospective accounts of professional reasoning and intended educational action, while owner-occupier interviews provided accounts of how these interactions were subsequently interpreted, applied, or experienced. Across the dataset, 236 instances were coded in which competences co-created through design interactions became connected to elements of owner-occupiers' practices. Of these, 111 concerned meanings (C → ME), 73 concerned material arrangements (C → MA), and 52 concerned further competences (C → C).

These counts indicate the relative analytical concentration of learning instances rather than their statistical prevalence. The competences-to-competences pathway (C → C) contained the fewest coded instances, while the competences-to-meanings pathway (C → ME) contained the most. The pathway to meanings gained additional significance in projects that were not initially framed as retrofit (e.g., renovation or extension projects). Table 5 summarises identified educational actions across pathways. The sections below present findings by pathway, beginning with competences to meanings (C → ME), followed by the other pathways, which are discussed concisely due to their comparatively lower frequency.

5.1. Competences to meanings (C → ME): Making retrofit worthwhile

Within the pathway of competences to meanings (C → ME), architects' actions focused on *making retrofit worthwhile* and relevant in relation to owner-occupiers' goals and aspirations. The most prominent theme involved *integrating retrofit into broader projects and practices*. Two forms of this integration were evident. The first form involved jointly exploring opportunities to extend or shift the project scope, creating chances for 'making the most of the situation.' The second form encouraged owner-occupiers' uptake of measures by better aligning retrofit with their wider aspirations and values.

5.1.1. Integrating retrofit with improvement projects

Across the dataset, architects most frequently enabled retrofit by reworking how projects were understood. This work was particularly evident in projects characterised by narrowly defined briefs or 'tunnelled' visions that often excluded more 'obvious' sustainable alternatives (AR-5), including retrofit. Architects described the need to 'look for opportunities while carrying out work,' framing this as intrinsic to 'proper' professional responsibility and something that occurred almost 'unconsciously' within practice (AR-7). Integration was perceived as generating more 'valuable propositions' by aligning retrofit with existing constraints and aspirations. As one interviewee (AR-5) explained:

Table 5
Structure of Themes. Source: Authors.

Learning Pathway	Educational Actions
Competences to Competences (C → C)	Making Retrofit Understandable Adapting to Live with Low-Carbon Measures Cultivating Retrofit Knowledge
Competences to Material Arrangements (C → MA)	Designing Out Risks
Competences to Meanings (C → ME)	Designing Out Risks in Existing Homes Designing Out Risks in Processes Making Retrofit Worthwhile Balancing Retrofit with Dwelling Integrating Retrofit with Improvement Projects

'Retrofit is not cheap! It is perhaps not cost-effective in the pure sense. It is not always an easy thing to reconcile. [...] each project would have its own set of constraints, and the client would have their own aspirations. Normally, if you can start to tie the two things together, then it becomes a more valuable proposition, should we say.'

Observations showed that the reconfiguration of worth developed iteratively rather than through a single recommendation. During an observed design meeting (AR-1 and OW-3), the architect revisited the written brief with the owner-occupier and connected the original desire for internal reconfiguration and improved access to the garden with broader retrofit possibilities. The owner-occupier described the resulting change:

'[This alternative] saw through all the difficulties! We looked at all those sorts of things I wanted, but I will have the insulation and all the heat pump and those sorts of stuff, which will make a better house for my son; hopefully, to inherit at some point. We suddenly changed that [brief]!'

The apparent 'sudden' change therefore represented the outcome of repeated movement between aspirations, design alternatives, cost, and anticipated family legacy. In this instance, the learning pathway operated by changing what counted as a valuable project rather than by transferring technical information alone. A similar connection between architectural form, aesthetic value, and retrofit potential emerged in a second observed case (AR-1 and OW-4):

'Option B is stunning in its simplicity, but then what it can offer inside; also, the idea of being that simple shape and having more Passive house and retrofit possibilities. [...] We've got the opportunity to build that in the existing footprint of what we have. I have not even thought of being able to do that. [...] I mean, I would rather spend all the money on that and never go out again!'

In some cases, the integration of retrofit required narrowing original ambitions. Architects encouraged the reallocation of resources from spatial expansion towards fabric upgrades, thereby destabilising established associations between value and additional space. Interviewees explained (AR-11, AR-13):

'Often, clients come thinking they want an extension at the back of the house. Very often, they do not need an extension; they just need to reorganise the house, and we are often in a situation where we are encouraging them to spend the money on improving the fabric of the house before they look for additional space.'

'We go and survey the house and say, you do not need an extension. You just need to change the arrangement of rooms, and then you'll have what you require for your lifestyle and save all this money that you can now spend upgrading your house properly. We, as architects, think it is obvious; they go, we would have never thought of that! But that is because we are architects.'

Through these interactions, retrofit became embedded within improvement projects rather than positioned as an additional or competing objective.

5.1.2. Balancing retrofit with dwelling

A second theme concerned architects' work in balancing competing meanings that shaped owner-occupiers' engagement with retrofit. Architects described their efforts to cultivate a 'sensitivity' around energy efficiency by helping owner-occupiers negotiate locally acceptable compromises between retrofit ambitions and broader aspirations for the home (AR-5, AR-12). In interviews, owner-occupiers described how design helped them negotiate acceptable compromises (OW-8, OW-13):

'I have this idea of a cosy lounge with a wood burner. I want to include a wood burner, and [the architect] was saying you cannot, if

you are going to go for a retrofit house. In the end, the compromise was that we would leave a space that could be used for a wood burner in the future if I felt I needed it. But of course, you do not. You just do not realise that you won't need it. We are quite happy without it!'

'Floorboards are a bit too bright compared to what I had in mind. But I think the ensemble is just flowing really, really well. [...] That is where the architect's vision was better than my own because she could see that by future-proofing the house, it meant using certain materials.'

Observations captured how architects facilitated local compromises to make retrofit feasible. For example, the architect and owner-occupier compared insulation samples to identify a thickness that balanced thermal performance with the visibility of the house's 'iconic' wooden beams, assessing the samples' visual effects and discussing their implications for heat loss (AR-4 and OW-6). This exchange produced locally acceptable compromises grounded in a deeper understanding of trade-offs. Fig. 1 shows some of these trials.

Beyond resolving conflicts between retrofit and wider meanings, architects also enabled new meanings of comfort and dwelling to emerge. For example, one architect (AR-11) described clients who came to use a highly insulated extension as their primary living space, redefining comfort and reducing heating demand in the remainder of the house. This account suggests that the comfort and everyday usability of the highly insulated extension came to outweigh the symbolic and aesthetic value of the original period rooms, influencing how occupants used and valued different parts of the home.

'They have this lovely detached family [house] from the late 1800s. They built this big extension at the back. What is really interesting is that they said they spend ALL their time there with the door shut to the rest of the house, where they have two living rooms with lovely period features. They said they turned off the heating in the rest of the house. Because in this highly insulated new extension at the back. They have art going on in there, and that is all they need.'

5.2. Competences to material arrangements (C → MA): Designing out risks

The pathway of competences to material arrangements (C → MA) captured learning related to the physical configuration of homes and the integration of low-carbon measures. In this pathway, architects frequently engaged in *designing out risks*. These efforts focused on risks in the retrofit process and the effective assembly of low-carbon measures. Process risks were posed by skill shortages, identified by architects (AR-13) as 'the biggest issue at the moment' in domestic retrofitting. Interviews and observations showed architects working with owner-occupiers to select suitably skilled contractors, as well as enabling owner-occupiers to act as the 'glue that holds it all together' (AR-13). Installation risks arose from 'hidden secrets' of existing homes (AR-12), which architects addressed by bringing 'design sense' to projects:

'With retrofitting, a lot of it is initially about stripping the building back physically, [...] in a design sense, and then looking at how do we put it all back together; what can we keep; what needs to change. It is just that all buildings often have some little hidden secrets for retrofitting!'

An episode from the same observed project demonstrated how material risk was managed through situated judgement rather than through the application of a standard technical solution. In one of the observed projects, AR-4 discouraged the use of rigid phenolic insulation despite its lower thermal conductivity because the inaccessible and irregular spacing between the existing roof rafters could prevent it from fitting effectively (AR-4 and OW-6). This episode shows that competence involved evaluating product performance in relation to uncertain existing conditions. The architect's educational contribution was



Fig. 1. Exploration of Workable Insulation Thicknesses. Source: Authors.

therefore not simply to identify the theoretically best material, but to make the consequences of contextual fit intelligible.

Furthermore, the analysis identified connections between learning in the pathway to material arrangements (C → MA) and goals and meanings (ME). For instance, one owner-occupier described architects' risk-management actions as helpful in managing 'the emotionality of the building works' (OW-12). Another participant linked these actions to avoiding a project that 'might have looked the same but would not have functioned in the same way' (OW-11). This alignment was also emphasised by architects (AR-8):

'They have an understanding of what they want to achieve, which is they want a warmer home environment. But the education on how that is achieved is normally very, very low. [...] So, the majority of the clients that I have do not know what they need to achieve their goals.'

5.3. Competences to competences (C → C): Making retrofit understandable

Learning in the pathway of competences to competences (C → C) included examples of architects' actions in *making retrofit understandable* for owner-occupiers. The most significant theme in this pathway concerned architects' actions in *cultivating retrofit knowledge*. Only in this pathway architects explicitly framed their role as an 'advisor'. One of the architects (AR-8) explained:

'I call myself a consultant and an advisor more than an architectural designer. Because that is one of the key things that you do in our profession is making sure that people understand what you are doing, why and how.'

Owner-occupiers also referred to their discussions with architects as a process of learning. One participant (OW-3) described 'discussions and idea phase' as a process 'about evolving and developing.' Examples of these educative practices were captured in observations. An observed exchange illustrated how technical information was translated through an everyday analogy (AR-1 and OW-3). The sequence reordered the explanation around an existing household competence, providing a bridge from familiar ventilation practices to an unfamiliar mechanical ventilation with heat recovery (MVHR) system:

- 'So, you could use it more like the vent that you use for over a cooker. Like the extraction, but it would also give fresh air. It would do both: bring in fresh, warm air that's heated by the stale, warm air going out.
- Do you put a mechanism in to do that, yes?
- There are loads of clever fans. It is called MVHR, Mechanical Ventilation Heat Recovery.'

In addition, the analysis found alignment between learning in the pathway to competences (C → C) and meanings (ME). One of the

architects (AR-10) stressed it was 'impossible' for architects to implement low-carbon measures without discussing technicalities. Another architect (AR-11) explicitly emphasised this alignment, noting that expanding owner-occupiers' understanding of retrofit could sustain their motivation to pursue retrofit:

'You know that somebody is 100% behind the project when they can explain the project back to you and talk about it as if it is their design. [...] then you know they have embraced the idea [of retrofit].'

5.4. Fragmented educational activities: Areas of limited evidence

Despite extensive educative engagement during early design stages, research findings highlight fragmentation of educational effort across project stages and suggest limitations in architects' educative reach. Among all the identified educational actions, *adapting to live with low-carbon measures* (C → C) received the least emphasis. Observations and interviews documented owner-occupiers' reliance on architects for this type of support. For example, observations of design meetings recorded discussions about learning how to dry clothes quickly in a house without radiators, an issue that was referred to as 'understanding the day-to-day stuff of a retrofitted house' (AR-1 and OW-3). In interviews, one of the owner-occupiers highlighted the need for hand-holding to 'relearn' how to live in their home and the dependence on architects to 'carry the house' (OW-13). However, this statement was followed by an expression of feeling abandoned:

'It is that feeling of someone really guiding me by the hand. Because, ultimately, I feel like [the architects] know the house better than me in some sense. [...] I have made decisions within the house, but I have been left alone with those decisions.'

The study also identified limitations in architects' use of drawings to design out risks within the pathway to material arrangements (C → MA). Although this pathway was moderately populated, emerging evidence suggests that drawings aimed at guiding the construction process with precision may hinder communication and learning. Architects in the study described 'inscribing the cleverness' of the best practices of retrofit into detailed drawings. They referred to these drawings as 'lines in the sand,' which sought to minimise 'room for interpretation' and reduce the chances of errors (AR-13, AR-14, AR-16). Nevertheless, owner-occupiers reported being unable to interpret the detailed drawings provided for their project and explained that prospective builders declined the work because it appeared too complicated (OW-7). Detailed prescription therefore operated ambivalently. It was intended to reduce the risk of incorrect installation, while potentially concentrating competence within the architectural profession and narrowing the range of practitioners able to participate.

6. Discussion

The discussion is organised around the study's empirical, conceptual,

theoretical and practical contributions (see Section 1). Section 6.1 synthesises the empirical findings across the three learning pathways, explaining how learning about retrofit unfolded in design interactions. Section 6.2 develops the conceptual argument that a central learning process involved the reconfiguration of worth. Section 6.3 develops the theoretical implications for conceptualising architects' agency. Section 6.4 turns to implications for practice and policy. Section 6.5 addresses the limits of architects' educational role.

6.1. Architects' role across learning pathways

The findings identify distinct educative practices enacted by architects across the three learning pathways. In the pathway to competences ($C \rightarrow C$), architects sought to make retrofit understandable through technical explanation and the development of retrofit knowledge (see Section 5.3). In the pathway to material arrangements ($C \rightarrow MA$), architects enabled retrofit by designing out procedural and technical risks (see Section 5.2). Most prominently, in the pathway to meanings ($C \rightarrow ME$), architects facilitated learning by making retrofit worthwhile (see Section 5.1). The variety of these roles in learning pathways responds to particular project requirements, including helping owner-occupiers to 'embrace the idea of retrofit', manage the 'little hidden secrets' of existing homes, and turn retrofit into 'valuable propositions' worth pursuing. The findings therefore illustrate how energy knowledge is shaped by the circumstances and requirements of particular projects.

Furthermore, the distribution of learning instances across pathways was notably uneven. The pathway to competences ($C \rightarrow C$) contained the fewest coded instances, whereas competences to meanings ($C \rightarrow ME$) included the largest number of coded instances, particularly in projects not initially framed as retrofit. However, the prominence of meanings does not diminish the role of material arrangements or competences. Learning in the pathways to competences ($C \rightarrow C$) and material arrangements ($C \rightarrow MA$) was closely intertwined with meanings. Results showed that learning in the pathway to material arrangements ($C \rightarrow MA$) helped owner-occupiers to manage the 'emotional burden' of retrofit and achieve what they wanted. Likewise, in the pathway to competences ($C \rightarrow C$), architects described technical understanding as supporting motivation and identification with retrofit goals. These connections suggest that making retrofit understandable and feasible could contribute to making it worthwhile. The analytical significance of meaning-oriented learning therefore rests on how technical understanding and material considerations contributed to changes in project judgement.

These findings are consistent with studies that locate energy knowledge within everyday life [13,14,49–52], and connect learning to interaction with building professionals within these settings [53,54]. The current study develops these accounts by showing how technical explanations and material judgements became connected with what owner-occupiers considered worth pursuing within particular projects. Building conditions informed which alternatives could be proposed, while owner-occupiers' aspirations shaped how those alternatives were evaluated. This provides a project-specific account of how the elements of practices were brought into relation through design interaction. Accordingly, the findings reflect recent accounts of the interdependent and project-specific character of retrofit decision-making [30,55–57], while extending them by specifying the analytical significance of the meaning-oriented learning pathway ($C \rightarrow ME$).

The exchanges associated with meaning-oriented learning show how influence could be exercised through reconsidering an apparently routine brief or questioning what counted as an improvement, without appearing as a separate act of energy advice. This helps make explicit the professional activity described in earlier research as 'invisible' [23] and 'quiet' [22]. The concentration of learning instances in the meanings pathway ($C \rightarrow ME$) shows that such influence occurs through the active negotiation of worth within broader home improvement projects. The present study specifies this activity through the connections formed,

challenged and revised in design interaction.

6.2. Reconfiguration of worth

A central contribution of this study lies in specifying how retrofit becomes worthwhile in practice. As discussed in Section 5.1, the findings show how architects helped owner-occupiers make the most of existing opportunities by linking retrofit to home improvement projects. This involved identifying opportunities to incorporate retrofit into planned maintenance, renovation or extension work, and reconsidering the aims against which project alternatives were judged. The significance of this reconsideration is visible in the difference between proposing an energy measure and reconsidering what the project was intended to achieve. In the exchange involving AR-1 and OW-3, revisiting the brief connected spatial reconfiguration with energy measures and the prospect of a home that could be inherited by the owner-occupier's son. Accounts of questioning the need for an extension similarly brought the relationship between additional space and a better home into discussion. In these examples, learning concerned the criteria by which alternatives were evaluated as well as the alternatives themselves.

Reconfiguration of worth therefore describes a change in how project possibilities were understood and compared. It provides a situated interpretation of transformative engagement, without assuming that these exchanges established a lasting change in environmental attitudes or measured energy outcomes. In the cases examined, worth encompassed comfort, aesthetics, spatial needs and family legacy alongside financial considerations and energy performance. The MVHR explanation in Section 5.3 made an unfamiliar system intelligible through an everyday analogy, while the material judgements in Section 5.2 connected product performance with the conditions of an existing building. Such exchanges provided resources for evaluating options in relation to household purposes. The contribution is therefore to show how technical understanding becomes involved in the negotiation of worth. It does not depend on treating information and valuation as competing explanations or on demonstrating that informational or financial constraints are generally less important.

The emphasis on worth is consistent with critiques of information-deficit approaches in energy research [7,10,14,43,44], and with relational research showing that owner-occupiers interpret retrofit through meanings associated with wider goals and aspirations [30,55]. This interpretation builds on research examining how project value is enacted through interactive valuation practices [68], iterative adjustment between architects and clients [67], the negotiation of retrofit meanings within a wider nexus of practices [34], and the relevance of residents' situated knowledge [59]. The specific extension is to connect valuation with the learning pathways through which energy performance becomes relevant to a developing home improvement project. These connections were particularly evident where retrofit was not part of the initial brief, giving an interactional account of the latent opportunities identified in renovation research [30,31]. Together, the findings specify how design interactions brought retrofit into project discussions and how learning contributed to the reconfiguration of worth.

6.3. Relational education and professional agency

Consistent with the account of learning developed in Section 3, education was embedded in the joint consideration of design propositions. Within the cases studied, architects' educative agency operated through establishing new connections and destabilising existing ones within the nexus of practices. As evidenced in Section 5.1, integrating retrofit into maintenance, repair, or extension projects required forging new links between energy efficiency and other project aims. Conversely, reallocating resources from extensions to fabric upgrades required destabilising assumed associations between spatial expansion and value. Similarly, balancing retrofit with aesthetic aspirations sometimes required challenging established preferences and habits. An

explanation, sample or alternative arrangement became consequential insofar as it related to what the owner-occupier was trying to achieve. For example, discussing insulation thickness alongside the preservation of valued beams made the performance and aesthetic consequences available for shared judgement.

These actions show how architects' educative agency was enacted through the interrelated work of connecting, challenging and balancing. This agency took shape through exchanges in which architectural expertise, owner-occupiers' knowledge and material conditions shaped the possibilities under consideration. The identified learning pathways make these operations analytically explicit by tracing how competences articulated and developed through interaction were involved in establishing, questioning and adjusting connections with meanings, material arrangements and further competences in owner-occupiers' practices. In this study, architects' educative agency was particularly evident in the meaning-oriented pathway (C → ME), where retrofit's relevance was negotiated in relation to other interconnected meanings associated with the home. Connecting brought energy performance into relation with owner-occupiers' aspirations; challenging questioned established assumptions about what constituted a worthwhile improvement; and balancing involved evaluating the consequences of different priorities to identify where aims could be aligned and where trade-offs were required.

The contribution is therefore to explain how professional agency was enacted through the intersection of architectural and owner-occupiers' practices, and how this influence acquired an educational character within the projects studied. This interpretation complements intermediary and middle-actor accounts of professional influence [18,76,77] by specifying how enabling influence was exercised through shared understanding and the joint evaluation of alternatives. It connects practice-theoretical accounts of knowledge and learning within practices [86] with an understanding of knowledge relevance as relationally accomplished through connections with the elements of the receiving practice [89]. The study thus contributes to relational and practice-theoretical accounts of agency [56,82] by showing how architectural expertise acquired influence through engagement with owner-occupiers' knowledge and material conditions, and how connecting, challenging and balancing shaped the understanding and evaluation of project alternatives.

6.4. Implications for practice and policy

The findings concerning worth and relational education provide a basis for rethinking the educational function of briefing. The examined design interactions show how a brief can become a site for reconsidering what constitutes a worthwhile project. This possibility is evident when discussions connect energy measures with owner-occupiers' aspirations, test whether additional space is necessary, or revisit priorities in the light of design alternatives. In relation to professional frameworks, this finding indicates the value of creating sufficient space for robust and reflexive dialogue between architects and owner-occupiers at the intersection of their practices. In the UK context, this aligns with efforts such as the *RIBA Passivhaus Overlay to the Plan of Work* [98], which advocates extending the briefing stages and adopting a front-loaded design approach. The present findings add an educational reason for investing in this early engagement to allow owner-occupiers and professionals to examine whether initial aims capture the possibilities of the existing home and how low-carbon options relate to those aims.

Additionally, the findings show that architects' educational practices often unfold iteratively rather than sequentially. Results indicate that establishing the worth of retrofit required destabilisation efforts and continual back-and-forth between design proposals (Section 5.1). The analysis also captured how learning along the pathways to competences (C → C) and material arrangements (C → MA) was connected with meanings (ME) (Sections 5.2, 5.3). These findings suggest that extended briefing could benefit from more scope for feedback and movement

between project stages. Therefore, results support previous proposals to conceptualise the Plan of Work as a circular process with possible leaps between stages [99,100]. While this study does not demonstrate the need for an entirely circular delivery model, it suggests that such adjustments can more accurately reflect the educative practices observed in these cases and provide resources to support the scaling up of these practices.

In policy terms, the findings suggest that opportunities for low-carbon measures may emerge within broader renovation and home improvement projects. This aligns with research advocating the use of existing household entry points, including planned renovation, to introduce energy-efficiency measures [30,31]. The findings point to a complementary enabling role for policy in creating conditions in which trusted professionals and owner-occupiers have sufficient time, resources and support to consider low-carbon possibilities within actual home improvement projects. This is consistent with Janda and Topouzi's [15] account of the 'learning story,' which emphasises participation, reflection and attention to the gap between technical potential and what is achieved within the complexity of real settings. Policy could therefore complement regulatory and financial measures by supporting situated forms of engagement through which professionals and households can work through the practical and evaluative complexities of retrofit.

Finally, the finding that retrofit worth was constituted through multiple considerations, including cost, suggests that financial support addresses one important dimension of value but may be insufficient, on its own, to generate engagement. This aligns with relational policy research arguing that retrofit programmes should integrate suitable financing with households' wider motivations [30]. In the cases studied, architects helped make these wider sources of value relevant and intelligible. At the policy level, this points not to positioning architects as universal delivery agents, but to combining financial provision with trusted, context-sensitive intermediation and design advice. This resonates with research highlighting the role of innovation intermediaries in configuring integrated retrofit business models [58]. The study provides a rationale for examining such combinations, whose accessibility and effectiveness require evaluation.

6.5. Limits of architects' educational role

Evidence in Section 5.4 qualifies the educational role identified above by raising questions about continuity of support. OW-13 described relying on architects to 'carry the house' while also feeling left alone with decisions. Together with discussions about learning the everyday routines of a retrofitted home, this account suggests that participation in design decisions does not necessarily resolve later needs for support. Such needs are consistent with research on learning to use low-carbon systems [101], the potential role of architects in supporting occupants [64], and the relationship between project delivery and post-occupancy practice [102]. The limited later-stage evidence in this research cannot establish how frequently support was insufficient or whether support differed systematically between project stages. Its analytical significance is to identify a possible tension within relational education: support that enables participation during design may also leave questions about how householders continue to act when professional involvement ends.

Additionally, the study identified tensions within material-oriented learning. Findings showed that highly detailed drawings intended to design out risk sometimes discouraged local builders due to their complexity. Thus, material precision intended to reduce installation risk could inadvertently constrain broader learning and participation. This finding is consistent with concerns about communication across disciplinary boundaries [102]. However, it does not establish that drawings generally block retrofit or that their intended risk-reduction benefits were realised. This suggests a need for research examining how technical drawings are discussed and interpreted in retrofit, and how their use supports or hinders shared understanding and participation.

7. Research limitations

Several limitations should be acknowledged. The study focused on a relatively small sample of architects working in micro-sized practices with explicit commitments to low-carbon retrofit. While this enabled in-depth examination of educative practices relevant to housing retrofit, it limits the generalisability of the findings across the wider profession. Hence, the findings are offered as a basis for analytic rather than statistical generalisation. The learning identified across the pathways reflects the interactional positions occupied by the architects, rather than inherent properties of architects themselves. Whether other building professionals who engage with owner-occupiers at a similar point in the design process exercise a comparable influence is an empirical question for further research.

In addition, the research concentrated primarily on early design stages. Accordingly, the study offers limited evidence on how the relational educative role identified here develops through construction and post-occupancy stages, where the findings themselves indicate that support for adaptation may weaken. Consequently, the long-term evolution of learning beyond early project phases remains underexplored.

Finally, the data were collected between March 2022 and February 2023. Subsequent developments in the retrofit policy and professional landscape are therefore not captured by the empirical material, although the study is concerned primarily with relational processes of design interaction rather than the evaluation of a particular policy regime.

8. Conclusion

This study shows how architects in low-carbon-oriented micro-practices supported owner-occupiers' engagement with retrofit through design interactions. Drawing on practice theory and nexus thinking, the analysis connects learning to technical competences, situated material judgement and the negotiation of meanings. Research findings demonstrate that meaning-oriented learning is the most prominent pathway, particularly where participants reconsidered what constituted a worthwhile improvement to their homes. The reconfiguration of worth therefore captures learning through changes in how project possibilities are understood and evaluated. Technical understanding and material feasibility inform these judgements. These findings characterise architects' situated agency as relational education. Professional knowledge becomes relevant through exchanges in which architects and owner-

occupiers connect technical possibilities with domestic experience, aspirations and building conditions. By specifying how these connections are formed, challenged and revised, the study complements intermediary and middle-actor perspectives with an account of the educative practices through which professional influence is enacted. Thus, the study provides an empirically grounded basis for rethinking briefing stages as dynamic sites for negotiating retrofit.

The findings concern processes within the selected cases and do not establish architects' comparative effectiveness or independently measured effects on retrofit uptake and energy performance. Reported difficulties with technical documentation and continuity of support also qualify the educational role identified. Future research should compare professional and delivery contexts and follow learning through construction and occupation, examining when these interactions support sustained household participation and how support can continue beyond early design. Additionally, the concept of worth warrants further theoretical elaboration. Identifying how worthwhile touchpoints emerge within different nexuses of practice can provide valuable insight into enabling large-scale retrofit transformation.

CRediT authorship contribution statement

Habib Ghasemi: Writing – review & editing, Writing – original draft, Visualization, Software, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Tara Hipwood:** Writing – review & editing, Validation, Supervision, Project administration, Conceptualization. **Peter Holgate:** Writing – review & editing, Supervision, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Participants' profile

Table A.1
Architect and Owner-Occupier Profiles. Source: Authors.

Panel A. Architects			
Firms	Participant(s)	Practice size (employees)	Data Source
Firm-1	AR-1, AR-2, AR-3	<5	Observation
Firm-2	AR-4	5–9	Observation
Firm-3	AR-5	5–9	Interview
Firm-4	AR-6	<5	Interview
Firm-5	AR-7	<5	Interview
Firm-6	AR-8	<5	Interview
Firm-7	AR-9	<5	Interview
Firm-8	AR-10, AR-11	<5	Interview
Firm-9	AR-12	<5	Interview
Firm-10	AR-13	<5	Interview
Firm-11	AR-14, AR-15	<5	Interview
Firm-12	AR-16	<5	Interview

(continued on next page)

Table A.1 (continued)

Panel B. Owner-Occupiers			
Project	Participant(s)	Project Type	Data Source
Panel B. Owner-Occupiers			
Project	Participant(s)	Project Type	Data Source
Project-1	OW-1, OW-2	Emergent	Observation
Project-2	OW-3	Emergent	Observation
Project-3	OW-4, OW-5	Emergent	Observation
Project-4	OW-6	Planned	Observation
Project-5	OW-7, OW-8	Planned	Interview
Project-6	OW-9, OW-10	Planned	Interview
Project-7	OW-11	Planned	Interview
Project-8	OW-12	Planned	Interview
Project-9	OW-13	Emergent	Interview

Data availability

The data that has been used is confidential.

References

- [1] B. Wood, The role of existing buildings in the sustainability agenda, *Facilities* 24 (1/2) (2006) 41–67.
- [2] Environmental Audit Committee, *Energy Efficiency of Existing Homes: Fourth Report of Session 2019–21*, London, 2021.
- [3] P. Bertoldi, et al., Transformative investment strategy for carbon-neutral residential buildings in the European Union, *Eng. Buildings* 347 (2025) 116232.
- [4] P. Bolton, *Energy efficiency of UK homes*, 2025. . p. 42.
- [5] Climate Change Committee (CCC), *Progress in reducing emissions*, 2022.
- [6] UK Green Building Council (UKGBC), *Net zero whole life carbon roadmap: A pathway to net zero for the UK built environment*, 2021. . p. 31.
- [7] W. Abrahamse, E. Matthies, Informational strategies to promote pro-environmental behaviour: Changing knowledge, awareness, and attitudes, in: *Environmental Psychology: An Introduction*, 2018, pp. 263–272.
- [8] K. Lucas, et al., Promoting pro-environmental behaviour: existing evidence and policy implications, *Environ. Sci. Pol.* 11 (5) (2008) 456–466.
- [9] N. Burnett, S. Hinson, I. Stewart, The UK's plans and progress to reach net zero by 2050, 2024.
- [10] J. Desmedt, G. Vekemans, D. Maes, Ensuring effectiveness of information to influence household behaviour, *J. Clean. Prod.* 17 (4) (2009) 455–462.
- [11] K. Simpson, S. Cockbill, P. Childs, Home energy renovation: UK owner-occupied household uncertainties, information and data needs. IOP Conference Series: *Earth and Environmental Science* 1085(1), 2022, p. 012046.
- [12] K. Gram-Hanssen, Understanding change and continuity in residential energy consumption, *J. Consum. Cult.* 11 (1) (2011) 61–78.
- [13] S. Guy, E. Shove, The sociology of energy, buildings and the environment: Constructing knowledge, designing practice 5, *Psychology Press*, 2000.
- [14] E. Shove, Beyond the ABC: Climate Change Policy and Theories of Social Change, *Environ. Plan. A* 42 (6) (2010) 1273–1285.
- [15] K.B. Janda, M. Topouzi, Telling tales: using stories to remake energy policy, *Building research and information : the international journal of research, development and demonstration* 43 (4) (2015) 516–533.
- [16] L. Vlasova, K. Gram-Hanssen, Incorporating inhabitants' everyday practices into domestic retrofits, *Build. Res. Inf.* 42 (4) (2014) 512–524.
- [17] K. Simpson, K.B. Janda, A. Owen, Preparing 'middle actors' to deliver zero-carbon building transitions, *Buildings and Cities* 1 (1) (2020) 610–624.
- [18] K.B. Janda, G. Killip, Building expertise: renovation as professional innovation, in: *Constructing green: The social structures of sustainability*, 2013, pp. 35–55.
- [19] K. Hemström, K. Mahapatra, L. Gustavsson, Architects' perception of the innovativeness of the Swedish construction industry, *Constr. Innov.* 17 (2) (2017) 244–260.
- [20] R. Luck, Participatory design in architectural practice: Changing practices in future making in uncertain times, *Des. Stud.* 59 (2018) 139–157.
- [21] F.J. de Haan, J. Rotmans, A proposed theoretical framework for actors in transformative change, *Technological forecasting & social change* 128 (2018) 275–286.
- [22] F. Samuel, *Why architects matter: evidencing and communicating the value of architects*, Routledge, 2018.
- [23] J. Till, T. Schneider, Invisible Agency, *Archit. Des.* 82 (4) (2012) 38–43.
- [24] S. Oliveira, et al., Reconceptualising sustainability practice research in architecture: radical ways of seeing and imagining, *ARENA Journal of Architectural Research* 8 (1) (2023).
- [25] F.M. Meijer, A. Straub, E. Mlecnik, Consultancy centres and pop-ups as local authority policy instruments to stimulate adoption of energy efficiency by homeowners, *Sustainability* 10 (8) (2018) 2734.
- [26] J. Edwards, Retrofitting traditional buildings for improved energy performance in the context of BSI PAS 2035, *Journal of Building Survey, Appraisal & Valuation* 9 (4) (2021) 294–304.
- [27] A. Owen, G. Mitchell, A. Gouldson, Unseen influence—The role of low carbon retrofit advisers and installers in the adoption and use of domestic energy technology, *Energy Policy* 73 (2014) 169–179.
- [28] J. Peltomaa, H. Mela, M. Hildén, Housing managers as middle actors implementing sustainable housing policies in Finland, *Build. Res. Inf.* 48 (1) (2020) 53–66.
- [29] K. Janda, G. Killip, T. Fawcett, Reducing carbon from the "middle-out": the role of builders in domestic refurbishment, *Buildings* 4 (4) (2014) 911–936.
- [30] D. Brown, et al., Rethinking retrofit: Relational insights for the design of residential energy efficiency policy, *Energy Res. Soc. Sci.* 120 (2025) 103863.
- [31] G. Killip, Latent market opportunities for low-carbon housing refurbishment, in: *Energy & Complexity conference*, 2011.
- [32] Department of Energy & Climate Change (DECC), *United Kingdom Housing Energy Fact File*, 2012.
- [33] E. Shove, M. Watson, M. Pantzar, *The dynamics of social practice: Everyday life and how it changes*, SAGE Publications, 2012.
- [34] T. Hipwood, Understanding low-carbon housing retrofit within a wider nexus of practices, *J. Archit.* 26 (4) (2021) 453–474.
- [35] Office for National Statistics (ONS), *Dwelling Stocks by Tenure*, UK, 2021.
- [36] C. Faure, et al., Household acceptability of energy efficiency policies in the European Union: Policy characteristics trade-offs and the role of trust in government and environmental identity, *Ecol. Econ.* 192 (2022) 107267.
- [37] N. Kerr, M. Winkler, Household investment in home energy retrofit: A review of the evidence on effective public policy design for privately owned homes, *Renew. Sust. Energ. Rev.* 123 (2020) 109778.
- [38] Climate Change Committee (CCC), *Progress in reducing emissions: 2023 Report to Parliament*, 2023.
- [39] W. Abrahamse, et al., A review of intervention studies aimed at household energy conservation, *J. Environ. Psychol.* 25 (3) (2005) 273–291.
- [40] N. Bergman, T.J. Foxon, Reframing policy for the energy efficiency challenge: Insights from housing retrofits in the United Kingdom, *Energy Res. Soc. Sci.* 63 (2020) 101386.
- [41] S. Barr, Strategies for sustainability: citizens and responsible environmental behaviour, *Area* 35 (3) (2003) 227–240.
- [42] P. Upham, et al., *Public Attitudes to Environmental Change: a selective review of theory and practice*, in: *Living with Environmental Change*, 2009.
- [43] E. Richard, N. Thuraiaraj, Behaviour change strategies for energy efficiency in owner-occupied housing, *Constr. Innov.* 13 (2) (2013) 165–185.
- [44] F. Wise, A. Gillich, P. Palmer, Retrofit information challenges and potential solutions: Perspectives of households, retrofit professionals and local policy makers in the United Kingdom, *Energy Res. Soc. Sci.* 119 (2025) 103866.
- [45] P.C. Stern, *New Environmental Theories: Toward a Coherent Theory of Environmentally Significant Behavior*, *J. Soc. Issues* 56 (3) (2000) 407–424.
- [46] B. Verplanken, S. Orbell, Attitudes, Habits, and Behavior Change, *Annu. Rev. Psychol.* 73 (1) (2022) 327–352.
- [47] K. White, R. Habib, D.J. Hardisty, How to SHIFT Consumer Behaviors to be More Sustainable: A Literature Review and Guiding Framework, *J. Mark.* 83 (3) (2019) 22–49.
- [48] P.-A. Tengland, Behavior Change or Empowerment: On the Ethics of Health-Promotion Strategies, *Public Health Ethics* 5 (2) (2012) 140–153.
- [49] A. Karvonen, Towards systemic domestic retrofit: a social practices approach, *Build. Res. Inf.* 41 (5) (2013) 563–574.
- [50] N. Nash, et al., Climate-relevant behavioral spillover and the potential contribution of social practice theory, *WIREs Clim. Change* 8 (6) (2017).
- [51] E. Shove, *Energy Knowledges*, in: *ECEEE Summer Study*, Spindleruv Mlyn, Czech Republic, 1997.
- [52] T.H. Christensen, S.P.A.K. Larsen, H.N. Knudsen, How to engage households in energy demand response solutions?, in: *eccee 2019 Summer Study on energy efficiency: Is efficient sufficient?* European Council for an Energy Efficient Economy, ECEEE, 2019.

- [53] S. Guy, Designing urban knowledge: competing perspectives on energy and buildings, *Environment and Planning C: Government and Policy* 24 (5) (2006) 645–659.
- [54] P.J. Vergragt, H.S. Brown, The Challenge of Energy Retrofitting the Residential Housing stock: Grassroots Innovations and Socio-technical System Change in Worcester, MA, *Technology analysis & strategic management* 24 (4) (2012) 407–420.
- [55] E. Bolton, et al., The relational dimensions of renovation: Implications for retrofit policy, *Energy Res. Soc. Sci.* 96 (2023) 102916.
- [56] L. Middlemiss, et al., Developing a relational approach to energy demand: A methodological and conceptual guide, *Energy Res. Soc. Sci.* 110 (2024) 103441.
- [57] A. Shibeika, S. Oliveira, Environmental analysis in UK modern methods of construction (MMC) housing: insights from early-stage architectural design process, *Archnet-IJAR: International Journal of Architectural Research* 20 (2) (2026) 463–477.
- [58] D. Brown, P. Kivimaa, S. Sorrell, An energy leap? Business model innovation and intermediation in the 'Energiesprong' retrofit initiative, *Energy Res. Soc. Sci.* 58 (2019) 101253.
- [59] S. Furman, K. Hadjri, Wasted expertise: Why retrofit should include residents, *Energy Res. Soc. Sci.* 119 (2025) 103894.
- [60] B.S. Zaunbrecher, et al., Intermediaries as gatekeepers and their role in retrofit decisions of house owners, *Energy Res. Soc. Sci.* 74 (2021) 101939.
- [61] T. Zohar, Y. Parag, O. Ayalon, Of agency, action, and influence: the middle-out mechanism for promoting a low-carbon energy transition, *Energy Res. Soc. Sci.* 72 (2021).
- [62] K. Reindl, Agency and capacity in the planning and design phase of building renovations, *Energ. Effic.* 13 (7) (2020) 1409–1425.
- [63] J.P.S. Siva, K. London, Investigating the Role of Client Learning for Successful Architect-Client Relationships on Private Single Dwelling Projects, *Archit. Eng. Des. Manag.* 7 (3) (2011) 177–189.
- [64] R. Luck, Learning how to use buildings: An exploration of the potential of design interactions to support transition to low-impact community living, *Buildings (Basel)* 4 (4) (2014) 963–977.
- [65] R. Horne, T. Dalton, Transition to low carbon? An analysis of socio-technical change in housing renovation, *Urban Stud.* 51 (16) (2014) 3445–3458.
- [66] P. Femenias, The role of the architect in sustainable housing transformation. Four Swedish case studies, *Nord. J. Archit. Res.* 31 (1) (2019).
- [67] A. Mertens, M. Bourguignon, C. Elsen, Navigating architectural process: tracking architects' and user-clients' habitus shock in private dwelling design, *Archnet-IJAR: International Journal of Architectural Research* (2026) 1–18.
- [68] M.S. Cıdık, V. Bowler, Project value as practice: Interactive valuation practices in architectural design projects, *Int. J. Proj. Manag.* 40 (4) (2022) 362–371.
- [69] F. Wade, N. Murtagh, R. Hitchings, Managing professional jurisdiction and domestic energy use, *Building research and information: the international journal of research, development and demonstration* 46 (1) (2018) 42–53.
- [70] The International Union of Architects (UIA), Shaping the 21st century's agenda of architectural education and the future role of the architect - speakers' outlines, UIA, 2024. : International Webinar.
- [71] RIBA Sustainable Outcomes Guide, Royal Institute of British Architects, London, 2019.
- [72] ARB Competence Guidelines: Sustainability, 2021.
- [73] N. Murtagh, A. Roberts, R. Hind, The relationship between motivations of architectural designers and environmentally sustainable construction design, *Constr. Manag. Econ.* 34 (1) (2016) 61–75.
- [74] J. Till, *Architecture depends*, MIT Press, 2009, p. 254.
- [75] C. Lorne, Spatial agency and practising architecture beyond buildings, *Soc. Cult. Geogr.* 18 (2) (2017) 268–287.
- [76] K.B. Janda, Y. Parag, A middle-out approach for improving energy performance in buildings, *Build. Res. Inf.* 41 (1) (2013) 39–50.
- [77] P. Kivimaa, et al., Towards a typology of intermediaries in sustainability transitions: A systematic review and a research agenda, *Res. Policy* 48 (4) (2019) 1062–1075.
- [78] M. Martiskainen, P. Kivimaa, Creating innovative zero carbon homes in the United Kingdom — Intermediaries and champions in building projects, *Environ. Innov. Soc. Trans.* 26 (2018) 15–31.
- [79] F. De Roeck, K. Van Poeck, Agency in action: Towards a transactional approach for analyzing agency in sustainability transitions, *Environ. Innov. Soc. Trans.* 48 (2023) 100757.
- [80] S. Huttunen, et al., Pluralising agency to understand behaviour change in sustainability transitions, *Energy Res. Soc. Sci.* 76 (2021).
- [81] P. Grootenboer, C. Edwards-Groves, S. Choy, Practice theory and education: Diversity and contestation, in: *Practice theory perspectives on pedagogy and education*, Springer, 2017, pp. 1–21.
- [82] A. Pichelstorfer, (Re)Configuring Actors in Practice, in: M. Jonas, B. Littig, S. Choy (Eds.), *Methodological Reflections on Practice Oriented Theories*, Springer International Publishing, Cham, 2017, pp. 79–92.
- [83] D. Nicolini, *Practice theory, work, and organization: An introduction*, OUP Oxford, 2012.
- [84] T. Schatzki, *The site of the social: A philosophical account of the constitution of social life and change*, Pennsylvania State University Press, 2002.
- [85] A. Hui, Variation and the intersection of practices, in: *The Nexus of Practices*, Routledge, 2016, pp. 64–79.
- [86] T. Schatzki, Practices and Learning, in: P. Grootenboer, C. Edwards-Groves, S. Choy (Eds.), *Practice Theory Perspectives on Pedagogy and Education: Praxis, Diversity and Contestation*, Springer Singapore, Singapore, 2017, pp. 23–43.
- [87] S. Kemmis, et al., Learning as Being 'Stirred In' to Practices, in: P. Grootenboer, C. Edwards-Groves, S. Choy (Eds.), *Practice Theory Perspectives on Pedagogy and Education: Praxis, Diversity and Contestation*, Springer Singapore, Singapore, 2017, pp. 45–65.
- [88] S. Kemmis, A practice theory perspective on learning: beyond a 'standard' view, *Stud. Contin. Educ.* 43 (3) (2021) 280–295.
- [89] S. Rudnicki, A. Kowalczyk, What makes knowledge relevant? A practice-theoretical perspective, *Minerva* (2025) 1–26.
- [90] A. Bryman, *Social research methods*, 4th ed, Oxford University Press, Oxford, 2012.
- [91] F. Erickson, Ethnographic microanalysis, in: N.H. Hornberger, S.L. McKay (Eds.), *Sociolinguistics and Language Teaching*, Cambridge University Press, 1995, pp. 283–306.
- [92] R. Schmidt, The methodological challenges of practising praxeology, in: D. Weenink, G. Spaargaren, M. Lamers (Eds.), *Practice theory and research: Exploring the dynamics of social life*, Taylor & Francis, 2016, pp. 43–59.
- [93] RIBA Business Benchmarking 2025: Executive Summary, Royal Institute of British Architects (RIBA), London, 2025.
- [94] T. Schatzki, A primer on practice, in: J. Higgs, et al. (Eds.), *Practice-Based Education: Perspectives and Strategies*, Sense Publisher, Boston, United States, 2012, pp. 13–26.
- [95] V. Braun, V. Clarke, *Thematic analysis: A practical guide*, SAGE Publications, 2021, p. 376.
- [96] V. Braun, V. Clarke, Conceptual and design thinking for thematic analysis, *Qual. Psychol.* 9 (1) (2022) 3.
- [97] E. Joy, V. Braun, V. Clarke, Doing reflexive thematic analysis: A reflexive account, in: F. Meyer, K. Meissel (Eds.), *Research methods for education and the social disciplines in Aotearoa New Zealand*, NZCER Press, 2023.
- [98] M. Siddall, *Passivhaus Overlay to RIBA Plan of Work*, Royal Institute of British Architects, London, 2022.
- [99] M. Topouzi, et al., Deep retrofit approaches: Managing risks to minimise the energy performance gap, . in *eccee 2019 Summer Study on energy efficiency: Is efficient sufficient?*, European Council for an Energy Efficient Economy, 2019. . Presqu'île de Giens, France..
- [100] M. Topouzi, G. Killip, A. Owen, Learning from 'horror' stories: A plan of work to reduce the performance gap in deep retrofit, in: *PLEA 2017: Design to Thrive*, Edinburgh, 2017.
- [101] T. Hargreaves, C. Wilson, R. Hauxwell-Baldwin, Learning to live in a smart home, *Build. Res. Inf.* 46 (1) (2018) 127–139.
- [102] R. Hay, et al., Post-occupancy evaluation in architecture: experiences and perspectives from UK practice, *Build. Res. Inf.* 46 (6) (2017) 698–710.