DIGITALISATION IN REGENERATIVE CITIES: OPPORTUNITIES AND CHALLENGES IN THE BUILT ENVIRONMENT

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The built environment increasingly focuses on delivering sustainable refurbishment and new-build projects to support regenerative city-building. Digitalisation is often positioned as a critical enabler through tools such as BIM, project planning software, and generative AI (GenAI). However, important questions remain about how these tools are used in practice and how professionals navigate emerging ethical and strategic challenges. This study explores how Built Environment Professionals (BEPs) engage with digital tools on live projects, including how professionals adopt, adapt, or resist GenAI in context. Guided by a Strategy-as-Practice (SaP) lens, the research draws on interviews, surveys, and two embedded case studies, one of which was led by a practitioner-researcher. Findings reveal that digitalisation is not experienced as a seamless transformation, but a situated, relational process shaped by professional judgement, discretion, and role-specific adaptations. While participants reported informal experimentation with GenAI, they also expressed uncertainty over authorship, accountability, and ethical use - particularly as AI functionality becomes embedded within everyday tools. These insights highlight the need to support digital tool adoption and the strategic enactment of digitalisation by professionals aiming for regenerative outcomes.

Keywords: digitalisation; GenAI; ethical frameworks; professional practices; technical competencies

INTRODUCTION

The ambition to build regenerative cities has reshaped construction discourse. Regeneration focuses on restoration, renewal, and the enhancement of ecological and social systems. Refurbishment and extension projects are critical to these efforts, particularly in urban contexts where reusing existing buildings reduces carbon, retains embodied value, and supports biodiversity and community resilience. These efforts increasingly rely on digital tools (e.g., GIS and digital twins) to address these complex ecological and social challenges with digitalisation enabling scenario modelling, participatory planning, and integrated decision-making (Moufid *et al.,* 2024). At the project level, the digital transformation of the built environment supports regenerative practices not merely through improved efficiencies, but also as strategic enablers of

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circularity, flexibility, and long-term value creation within construction and design workflows (Konietzko *et al.,* 2023). Regeneration is thus not only a design aspiration but a digitally mediated professional practice

While digitalisation is now central to construction discourse, how it is used in the everyday work of regenerative city-building remains surprisingly opaque. Little attention has been paid to how Built Environment Professionals (BEPs) engage with digital tools in complex, site-based practices. In projects that blend refurbishment with new-build elements, digitalisation unfolds not as a seamless system but as a situated, strategic activity shaped by professional judgement, improvisation, and collaboration. Despite growing enthusiasm for digital transformation in the built environment, there is limited understanding of how professionals implement digital tools within the messy, negotiated space of live construction projects. Digitalisation unfolds less as a formal rollout and more as a negotiated, professional activity - particularly in refurbishment and extension work. Renewal goals intersect with legacy constraints, fragmented systems, and interdisciplinary demands. Professionals must navigate diverse tools, shifting client expectations, and project-specific constraints. By investigating how Built Environment Professionals (BEPs) strategically implement digitalisation in refurbishment and extension projects that contribute to regenerative city-building, this study offers new insight into the strategic dimensions of delivering regenerative city-building in practice.

LITERATURE REVIEW

The following literature review situates this inquiry within broader debates on regeneration, digital innovation, and professional agency in construction.

The ambition to build regenerative cities has redefined urban development, shifting focus from growth and efficiency to long-term ecological renewal and social resilience. This paradigm reframes the built environment as a site of repair and restoration rather than extraction and expansion which prioritises biodiversity, adaptive reuse, and future-oriented architectural thinking. (Lehmann, 2019; Arup,2024). These perspectives challenge traditional notions of professional performance by shifting emphasis from delivering predefined outputs to enabling ongoing environmental and social regeneration. This reconceptualisation requires professionals to engage more strategically with adaptive reuse, stakeholder value, and long-term resilience - demands that digital tools must now support in practice, not just in theory.

Much of the academic literature on digitalisation aligns with this aspirational framing but often assumes digital tools can be smoothly adopted into practice. For example, GhaffarianHoseini *et al. (*2017) emphasize the environmental benefits of Building Information Modelling (BIM), framing it as a vehicle for high-performance design and cross-disciplinary integration. Similarly, Lu *et al. (*2017) highlighted BIM's potential for reducing waste and improving lifecycle decision-making. However, despite their sustainability focus, both studies are rooted in new-build contexts and rely on data consistency, controlled sequencing, and technical standardisation assumptions which are hard to apply in the context of refurbishments and retrofits (a fundamental component of building regenerative cities). These assumptions overlook the praxis of digitalisation - the situated, adaptive work of professionals dealing with legacy buildings, fragmented information, and evolving client needs.

This limitation becomes more apparent when digitalisation is examined through a sociotechnical lens. Dossick and Neff (2010), for instance, demonstrate that BIM does not eliminate professional silos but often reinforces them, requiring relational work to bridge institutional and cultural divides. Building on this, Forbes, and Ahmed (2021) argue that successful digital delivery is not just about systems, but the invisible, informal labour professionals undertake to align expectations, translate outputs, and resolve inconsistencies. These insights challenge the tool-focused assumptions of earlier work by reframing digitalisation as a negotiated and discretionary activity. These informal acts reflect not just workflow adaptations but practices - the shared norms and routines that shape how digital tools are enacted across project teams. Whyte (2019) extends this thinking by showing how digital information platforms reshape project delivery models, often redistributing responsibility and altering inter-professional boundaries. This repositioning creates opportunities and ambiguities, requiring practitioners to exercise judgement and strategically reinterpret their roles. Consequently, digitalisation becomes a technical shift and a reconfiguration of power, agency, and coordination - especially relevant in retrofit contexts where professional judgement must override rigid workflows. These evolving responsibilities highlight the importance of practitioners themselves - those actors who shape strategy not by following formal plans but by adjusting tools, translating outputs, and negotiating value in context.

Professional body guidance presents digitalisation as a structured and predictable process. The CIOB offers an Artificial Intelligence Playbook (CIOB, 2021) which links digital proficiency to sector-wide productivity and quality gains, while the UK Government's Construction Playbook (2021) frames digitalisation as integral to modern procurement reform. Although these reports offer valuable frameworks, they overlook the iterative and situational realities of project delivery, especially in non-standardised refurbishment projects. Their emphasis on compliance and optimisation leaves limited room for professional discretion, adaptation, or client communication, which are critical to regenerative outcomes. Recent guidance addresses these gaps by linking digitalisation with value and sustainability frameworks. For example, the UK Green Building Council (2022) connects digital workflows to whole-life carbon accounting and retrofit innovation. In contrast, the Construction Innovation Hub's Value Toolkit (CIH, 2021) promotes data-driven decision-making to optimise social and environmental value. Likewise, the CIBSE (2022) offers integration guidance for digital building services in complex environments. Despite expanding the discourse beyond efficiency, these documents rarely engage with the ambiguity and resistance professionals encounter when applying digital tools in practice.

From a theoretical perspective, Succar and Kassem (2015) proposed a multilayered model of BIM adoption that distinguishes multi-level project environments. Although this model acknowledges complexity, it still implies that alignment across these levels is possible through planning and coordination. In contrast, Orlikowski (2000) argues that technology use is not predetermined but emergent, constituted through users' situated actions and institutional contexts. This practice-based lens is especially useful in construction, where professionals regularly confront conflicting priorities and incomplete information, requiring responsive strategies rather than strictly adhering to tool logic.

While these sociotechnical and practice-based critiques have focused on BIM and conventional digital tools, the increasing presence of artificial intelligence (AI) - and especially generative AI (GenAI) - adds further urgency to these concerns. While

artificial intelligence (AI) refers broadly to technologies that simulate human intelligence, this study is particularly concerned with Generative AI (GenAI) - tools that produce new content such as text, images, or specifications, and are increasingly embedded in everyday software. Regona *et al. (*2022) showed that GenAI in construction is unregulated and adopted informally without ethical oversight. Similarly, Boyd and Harding (2025) examined how GenAI reshapes the traditional boundaries of authorship and expertise in PhD supervision. These insights are directly relevant to the built environment, where client trust, professional identity, and decision accountability remain central. Despite the growing interest in AI, few empirical studies have explored how it intersects with everyday projects in a regenerative context. Moreover, limited methodological research focuses on how digitalisation is enacted in real-time collaboration. Most existing studies rely on post-hoc surveys or implementation case studies, leaving the digital strategy under-examined.

These dynamics align with sociotechnical and practice-based perspectives, emphasising that digital tools are not neutral systems but are enacted through use. Orlikowski (2000) argues that the meaning and impact of digital tools emerge not from their technical features alone but from how they are embedded within local routines, user judgment, and organisational norms. Nicolini (2012) similarly highlights that professional practice is situated and contingent, shaped by how individuals interpret and adapt technologies within institutional and cultural settings. This perspective is particularly relevant now, as GenAI functionality becomes increasingly embedded within everyday software systems - often with little formal oversight or training. As digital tools evolve, professional discretion, informal adaptation, and ethical ambiguity remain central to how they are enacted.

METHOD

To understand how digitalisation is strategically enacted on the ground, this study follows the everyday professional activity of Built Environment Practitioners across live construction settings. It adopts a qualitative research design informed by the Strategy-as-Practice (SaP) framework (Jarzabkowski *et al.,* 2016), which conceptualises strategy not as a fixed plan but as a situated activity enacted through professional work The framework distinguishes between praxis (the activity through which strategy unfolds), practices (the tools, norms, and routines structuring work), and practitioners (the agents who bring experience and discretion). This allows digitalisation to be understood not as a static shift in tools or standards but as a live, negotiated process - produced through the situated actions of BEPs working in complex environments.

The research was conducted in three stages. First, 12 BEPs working in architecture, engineering, quantity surveying, and project management completed a scoping questionnaire. This provided initial insights into how the 3Ps played out in everyday work settings, helping to refine the interview focus and guide subsequent data collection. Secondly, 20 semi-structured interviews were conducted with professionals at varying levels of seniority. The interview guide was explicitly mapped to the 3Ps framework. Participants were asked to describe how they used digital tools on specific projects (praxis), how they navigated or adapted guidance such as BIM protocols or cost standards (practices), and how their professional judgment shaped or resisted standardised digital approaches (practitioners). Interviews were conducted via telephone and transcribed.

Thirdly, two embedded case studies were conducted in central Edinburgh. Each involved a refurbishment-led redevelopment project with full strip-outs, reconfiguration, and substantial new-build extensions. The first case study involved the full refurbishment and adaptive reuse of a Georgian townhouse in central Edinburgh, combined with major new-build extensions to the front, side, and rear. These additions significantly expanded the building's footprint and functional capacity. The project was privately commissioned and required strategic coordination across disciplines to retain heritage elements while supporting densification and improved energy performance key regenerative aims.

The second case study focused on the redevelopment of a city-centre property into fifteen studio apartments. This included a complete internal strip-out and spatial reconfiguration, supported by a substantial new-build extension. The hybrid nature of the project demanded close integration of architectural, structural, and services input within constrained site conditions. Regenerative value was delivered through reuse of existing fabric, increased housing density, and improved environmental performance targets. These cases offered insight into how digitalisation was enacted across professional roles and boundaries. The researcher worked as the contractor's Quantity Surveyor on both projects and maintained detailed reflexive notes capturing informal communication, tool use, and professional improvisation. While this insider role provided privileged, real-time access to strategic digital practices as they unfolded on live projects, it also required continual reflexivity to mitigate potential bias. All data were coded thematically using the 3Ps: Praxis captured situational problem-solving and tool improvisation; practices referred to workflows, standards, and team norms; and practitioners highlighted judgement, role tension, and collaboration. This structure supported a coherent analysis of how digitalisation unfolded as a strategic, enacted process within regeneration projects, rather than something imposed from above.

FINDINGS

Across the scoping questionnaire, 20 semi-structured interviews, and two embedded case studies, digital tools were found to shape - and sometimes constrain - professional judgement, collaboration, and communication in ways that diverged from their intended functionality. Rather than streamlining delivery, digitalisation frequently introduced friction, demanding informal workarounds and discretionary responses that exemplify praxis - the unfolding, situated activity through which strategy is enacted in everyday work.

Three strategies emerged from the data analysis:

Digital workflows
Digital tools were shaped more by individual workarounds and project constraints than by formal standards or shared protocols. In both case studies, professionals used a mix of software - AutoCAD, Revit, BIM, Excel, CostX, Microsoft Project, OneDrive, and Dropbox - without a unified digital environment. In Case Study 1, for example, the architect uploaded design models to OneDrive while the structural engineer worked independently in Revit. The client's Quantity Surveyor used CostX but generated outputs the client struggled to interpret. The contractor's QS, also the embedded researcher, translated these into Excel: "The client was confused by the CostX files - they simply didn't understand them. I had to rework everything into Excel so they could follow what was being costed and why." Although informal and often invisible, this discretionary labour was central to maintaining project momentum

and client trust. One architect said: "There's pressure to make the model think for us, but that's not how real projects work."

This emerging strategy shows that BEPs do not experience digitalisation as a standardised or universally enabling process. Instead, it is a context-dependent, relational practice requiring continual adaptation and negotiation.

Experimentation with generative AI
Another recurring pattern was the quiet, informal experimentation with generative AI (GenAI). Across roles, participants described unacknowledged but intentional use of GenAI tools. A graduate architect said: "Sometimes I use it just to shake up my thinking, though I'd never submit anything straight from it. "A Quantity Surveyor reported using GenAI to interpret manufacturer data and draft specification content: "It's helpful, but you have to check everything - I treat it like a junior assistant." A structural engineer described it as a "grey area - helpful, but I would not want to rely on it."

This quiet experimentation reflected a mix of curiosity, caution, and critical awareness. Participants viewed GenAI as a tool for creative prompting and productivity gains yet remained wary of its opacity and ethical implications.

Ethical consideration and professionalism
The final emerging strategy was navigation of ethical and professional issues concerning the use of GenAI. A project manager reflected: "There is no real rulebook. It's just… try not to cross a line, even though you don't know where the line is." Concerns over authorship, traceability, and professional deskilling surfaced across professions. One senior architect worried: "If younger staff get too used to relying on AI, what happens to their ability to problem-solve or think through a design on their own?" Participants also noted that software tools increasingly include AI-driven features without clear visibility. A QS remarked: "It's hard to tell what's the software and what's you anymore - there's no flag that says, 'AI did this bit.'"

These experiences pointed to more profound uncertainty. GenAI use was undocumented and rarely discussed, creating significant ambiguity.

Summary
Underlying all these observations was a clear display of strategic agency. Rather than implementing digital tools as instructed, professionals exercised discretion and judgment to adapt them to evolving site realities, client understanding, and interdisciplinary needs. These acts of adaptation and reinterpretation demonstrate the praxis of digital strategy: BEPs did not receive systems passively but actively shaped them in service of collaboration and regenerative intent. These findings raise important implications for professional judgement, ethical innovation, and digital agency - further explored in the following discussion.

DISCUSSION

What emerges from these findings is not a failure of digitalisation but a revealing portrait of how professionals actively shape it - quietly, experimentally, and sometimes uncomfortably. Rather than simply adopting tools, in the way described in literature (c.f. Ghaffarianhosseini, 2017), BEPs negotiate the space between possibility and responsibility, transforming digital friction into strategic opportunity. These findings challenge the assumptions of linear digital transformation. They show that digitalisation is not something received or implemented but something enacted. It is shaped by people, not platforms, and delivered through discretion, not directives.

BEPs are not simply adopting digital tools - they are strategically enacting them in response to complex project realities, professional responsibilities, and emerging ethical challenges. This supports and extends assertions that digitalisation can reinforce siloed approaches and relies on professionals to align expectations and resolve inconsistencies (Dossick and Neff, 2010; Forbes, and Ahmed, 2021) and shows that rather than experiencing digitalisation as a coherent, top-down transformation, participants described it as fragmented, improvised, and shaped by personal judgement. This reinforces the core argument of the Strategy-as-Practice (SaP) framework: that strategy is not held in documents or systems but is something professionals actively do in situated contexts (Orlikowski, 2000).

The use of tools such as Revit, CostX, Excel, and GenAI did not unfold in predictable or standardised ways. Instead, BEPs engaged in situated strategising - adapting workflows, translating outputs, reformatting content for client comprehension, and responding to the shifting demands of regeneration-led refurbishment. These examples align closely with the SaP concept of praxis: the lived, discretionary actions through which strategy unfolds in daily work. Unlike the sequential and stylised models of digitalisation described by professional institutions digitalisation was not implemented uniformly but flexibly adjusted to fit the nuanced realities of live construction sites, and the messy realities of refurbishment and retrofit projects.

Digital practices were also shaped by institutional expectations, cultural norms, and disciplinary routines, reflecting what SaP refers to as practices. Architects used GenAI for design ideation; Quantity Surveyors applied it selectively to aid specification drafting; engineers were more cautious, concerned about data accuracy and liability; and Project Managers navigated ethical uncertainty with little formal guidance. These role-based distinctions highlight how practices are informed by and constrained by professional identities, regulatory expectations, and risk tolerance.

Crucially, this study illuminated the importance of practitioners who exercise discretion to make tools workable. Professionals described developing informal workarounds, translating complex files into more accessible formats, and deciding when to trust or override digital outputs. These actions were not acts of resistance but of responsibility. One participant noted, "It's hard to tell what the software is and what you are anymore." Such reflections emphasize the ambiguity introduced by embedded AI features, where machine-generated content lacks visibility and traceability, leaving professionals accountable for validating outputs they did not fully author. These ambiguities resonate with Boyd and Harding (2025) findings on the ethical and practical complications of GenAI on relationships and authorship.

The increasing presence of GenAI embedded within standard platforms - often without clear labelling or oversight - exacerbates this uncertainty. Without dedicated training, ethical protocols, or institutional support, professionals are left to navigate AI-enhanced outputs using personal judgment and tacit knowledge. This demands more than technical competence; it requires ethical discretion, creative interpretation, and relational communication - mainly when outputs inform clients or coordinate teams. These behaviours show that digitalisation is not simply an input-output process but a socially and ethically mediated practice, supporting Regona *et al.* (2022) in showing that digitalisation tends to be unregulated and adopted informally without ethical oversight.

These dynamics are particularly significant in regenerative city-building, where project complexity, environmental goals, and client expectations must be continually

balanced. Regeneration is not delivered through tool adoption alone - it is enacted through the situated work of professionals negotiating between constraints, systems, and values. In these everyday acts of adaptation, clarification, and discretion, regeneration becomes real - not as an abstract ideal but as a collaborative practice grounded in the strategic work of BEPs.

Limitations

This study offers insights shaped by the specific context of refurbishment-led projects in central Edinburgh. While the findings are not statistically generalisable, they provide transferable insights applicable to similar construction settings - particularly those grappling with fragmented workflows, legacy systems, and the informal use of emerging digital tools.

Future research

Future research could extend these findings to other geographies, larger-scale infrastructure projects, or firms with more advanced digital strategies and formalised AI governance. Further studies might also incorporate perspectives from clients, planners, and regulators to understand better how digitalisation supports regenerative construction across the full project ecosystem. Exploring longitudinal impacts of GenAI integration, professional deskilling, and digital ethics in practice would also offer valuable contributions to the evolving discourse.

CONCLUDING COMMENTS

This study explored how Built Environment Professionals (BEPs) strategically implement digitalisation in refurbishment and extension projects that contribute to regenerative city-building. Guided by the Strategy-as-Practice (SaP) framework the research found that digitalisation is neither smoothly adopted nor categorically resisted. Instead, professionals navigating complex project realities actively interpret, adapt, and enact it.

The findings revealed that praxis - the situated doing of strategy - emerged through discretionary actions that made digital tools workable in live contexts. From reformatting technical outputs to bypassing rigid systems and favouring more responsive alternatives, these acts reflect strategic responsiveness to legacy conditions, fragmented workflows, and regeneration goals. Practices, including disciplinary norms and tool routines, shaped how digitalisation unfolded across professional roles. Architects, engineers, Quantity Surveyors, and Project Managers engaged with digital tools differently, reflecting their professional values, institutional expectations, and perceived risks. These role-specific patterns show that digital workflows are not standardised processes but socially constructed responses to contextual demands. Crucially, practitioners functioned as strategic agents, using judgement to bridge technical limitations and ethical uncertainty. This was particularly evident in GenAI's undocumented, experimental use and the growing presence of embedded AI within everyday software. Without clear authorship markers or institutional policy, professionals bore responsibility for interpreting and validating outputs - often relying on tacit knowledge, peer exchange, and instinct to maintain quality and trust.

This paper contributes to construction management literature by reframing digitalisation as a socially and ethically situated process - one that is shaped not by platforms or systems, but by the everyday work of practitioners. If digital tools are to meaningfully support regenerative city-building, policy, research, and practice must

move beyond top-down deployment to support the situated, discretionary, and strategic labour already being enacted by professionals.

By highlighting these situated adaptations, the research addresses the broader 'so what' question: Achieving regenerative city objectives depends heavily on strategically aligning digital practices across professional silos. This alignment would support more effective management of embodied carbon, enhanced lifecycle sustainability, improved stakeholder communication, and greater transparency in urban development processes. The study thus contributes to knowledge by demonstrating how digital strategy enactment - when strategically integrated rather than informally fragmented - can improve outcomes for regenerative urban development.

In direct response to the research question, the findings show that digitalisation is strategically enacted not through unified systems or prescriptive workflows, but through the situated, interpretive, and discretionary practices of BEPs. These acts of professional judgement and cross-disciplinary coordination are what enable digital tools - both established and emerging - to support regenerative city-building in complex refurbishment and extension projects.

More broadly, the research emphasizes the importance of acknowledging professional judgement, interpretive labour, and contextual responsiveness as key enablers of meaningful digitalisation in the built environment. It offers theoretical and practical insights into how regenerative ambitions can be more effectively realised in everyday construction practices, shaping more cohesive, resilient, and sustainable urban futures. It is not systems that deliver strategy - it is people.

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