Reclaiming Productivity: Critical Perspectives on Speculative Futures in the Architecture, Engineering, and Construction Industry

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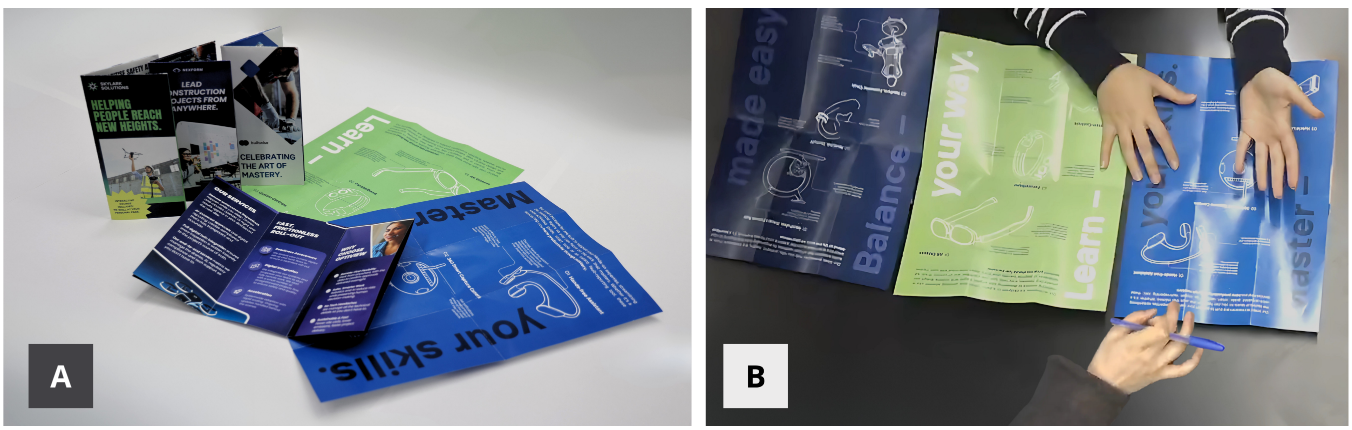

Figure 1: Drawing on speculative design practices [24, 79] and in close collaboration with stakeholders from the Architecture, Engineering and Construction (AEC) industry, we designed three sets of speculative brochures (A). These brochures depict alternative technological futures, used to spark critical reflection with AEC industry representatives across various factions and expertise (B), on what they value most about work.

ABSTRACT

New technologies are often introduced into organisations with promises of increased productivity. Yet productivity is often narrowly defined, and the impacts of technologies on future work practices are poorly understood. This paper reports on workers' concerns and reflections on future work practices in the Architecture, Engineering and Construction industry. In a series of semi-structured interviews, we engaged 17 industry participants, who responded to a set of speculative design brochures that imagine alternative technological futures. The findings show workers experience erosion of job satisfaction, shared purpose, and embodied craft. Drawing on participants' reflections, we propose that emerging technologies should (1) reclaim productivity as a pathway to job satisfaction and slowing down to innovate, and (2) bridge knowledge work and embodied craft, making knowledge creation more inclusive and streamlined across services. We discuss how technology can both mediate and reinforce power dynamics between executives and employees, and explore the impacts of design choices shaping the future of work.

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CCS CONCEPTS

• **Human-centered computing → Interaction design process and methods**; **Interaction design theory, concepts and paradigms**; **Empirical studies in HCI**.

KEYWORDS

Productivity; Speculative Design; Future of Work, Work Satisfaction, Critical Design, Architecture, Engineering, and Construction Industry

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1 INTRODUCTION

The pursuit of productivity is an enduring ambition of workplace technologies. Human-Computer Interaction (HCI) research has aimed to increase productivity of workplace technologies by improving task completion times, increasing throughput or reducing error [81]. Whilst these initiatives have had success, a focus on speed and throughput inadvertently proliferates "busy work" [100] and not taking sufficient account of employee's "personal productivity" [46], such as job satisfaction and long-term career benefits. There is growing concern that by limiting the framing of productivity only to organisational-level concerns (e.g. device usage duration, task completion, time spent on task), we may be neglecting broader notions of productivity, such as self-reflection, [15, 42, 50, 102], wellbeing [17, 29, 44, 57, 88], and collaboration [25, 27]; all of which are needed to create valuable work and realise the social benefits of productivity [65, 91].

There are two key HCI research challenges which need to be addressed to help workers reclaim productivity as an indicator of better working conditions and to help innovators improve their design of productivity technologies.

The first challenge concerns how productivity is designed for and framed. HCI research frequently relies on self-reported perceptions of productivity (e.g. [44, 64, 88]), influenced by subjective experiences and attitudes [33, 46, 48]. While these self-reports acknowledge the importance of workers' wellbeing and satisfaction, they typically frame productivity in organisational terms, such as quantity of outputs (e.g. meeting monthly targets [44]) or efficient use of time (e.g. [33]). We argue that HCI researchers should also consider how productivity could be broadened to consider how employees might achieve their own goals, such as greater job satisfaction or self-efficacy [46].

The second challenge concerns the scope of productivity research. Current workplace research tends to investigate specific occupational categories such as knowledge work (e.g. [13, 83, 96]), gig work (e.g. [38, 58, 105]), factory work (e.g. [7, 16, 72]), or trades and crafts (e.g. [53, 59, 103]). This falls short of acknowledging how workplace technologies are influenced by an industry's systemic norms and economic pressures [91], where people in different roles often rely on each other to complete shared tasks or produce tangible products. These interdependencies suggest that industry-wide investigations into work practices are important, yet remain largely under-explored in HCI.

We explore these two challenges — framing productivity to include personal perspectives and system-wide interdependencies — by working with people in the Architecture, Engineering and Construction (AEC) industry. We engaged industry practitioners from different career stages and areas of expertise, asking them to consider *speculative futures* and to reflect on how productivity intersects with job satisfaction, skill acquisition, safety, and output quality by interrogating alternative technological futures. In doing so, we asked the research questions:

RQ1: What are the issues and opportunities for work practices in the AEC industry posed by emerging technologies?

RQ2: What are the implications for a critical analysis of technologies being developed today?

To investigate these questions, we apply speculative design [24, 79] as a method for envisioning and critically examining futures of work. Working with industry representatives and informed by prior research on emerging technologies in the AEC sector, we created a set of *speculative brochures* **(Figure 1)**. We recruited 17 participants across diverse roles in the AEC industry, for a series of semi-structured interviews to interrogate the speculative brochures. The speculative brochures were designed to provoke reflections on how technologies might reshape future work practices and to raise questions about their consequences for the wider industry.

The findings are presented as two major themes, each of which are critically examined using Virilio's *en negatif* [99], which assumes well-meaning technological solutions often give rise to new challenges of their own.

The first theme concerned productivity, showing how participants across different roles (executives, employees, trade-workers, knowledge-workers) challenged efficiency-centric views of productivity, emphasising that productive work can also be satisfying, less frustrating, and more sustainable. They described how improving productivity sometimes requires slowing down to learn new technologies, resolve coordination issues, or support downstream collaborators, thereby highlighting a tension between short-term and long-term gains.

The second theme concerned embodied work, showing how participants stressed the importance of embodied, hands-on knowledge in an industry whose outputs are physical and tangible. In the AEC industry, cognitive and embodied forms of expertise are often inseparable — knowledge work requires understanding how building materials are used and trade work requires an understanding of project scheduling to meet building requirements. While emerging tools such as AI, robotics, and AR were seen as offering support for training and safety, and may address the intersection of cognitive and embodied work, participants worried that automation may create a "shortcut culture" or sidelines tacit expertise. These insights led to respective design provocations, which in-turn form the basis of the paper's key contributions:

- **Reconciling Productivity and Job-Satisfaction:** The use of technology to achieve productive goals should not be

limited to efficiency considerations alone. Technologies can employ efficiency as a means of achieving greater job satisfaction by, paradoxically, encouraging slowing-down and reflexivity. Drawing on AEC workers' reflections on speculative futures, we raise how HCI as a field needs to further investigate the link between productivity and factors like job satisfaction and self-efficacy.
- **Coordinating embodied work and knowledge work:** We highlight the limitations of technologies that assume a divide between knowledge work and embodied work. We suggest emerging technologies, such as extended reality and generative AI, can more actively value tacit knowledge, which is essential for many workers who produce tangible products. This use of technology to coordinate embodied work and knowledge work, particularly in the AEC industry, contributes to job satisfaction and more human-centred perspectives to productivity.

2 RELATED WORK

2.1 Architectural, Engineering and Construction (AEC) Industry

The AEC industry is vital for building and maintaining physical infrastructure, yet it faces growing scrutiny for its lack of sustainability, safety, and productivity gains. McKinsey reports that between 1994 and 2013, improvement in productivity for the AEC industry is 1.7 times less than productivity improvement in the manufacturing industry[1].

The AEC industry now faces systemic challenges and pressure to improve productivity, particularly in the wake of a global housing crisis. Barriers include skills shortages, limited training access, high costs, devaluation of traditional expertise, fragmented project structures, and regulatory hurdles [18, 89]. These socio-political challenges are complex; affected by government funding, workplace policies, education systems, and cultural perceptions of construction work.

Various technologies have been used in an attempt to address the above challenges. These include: additive manufacturing (3D printing) to create complex structures with less waste [71]; extended reality to support training, as well as the assembly and maintenance of physical assets [2, 34]; robotics that automate repetitive or hazardous tasks [9]; 3D building replicas, such as digital twins or Building Information Modelling (BIM) tools, used to facilitate real-time collaboration [2]; Internet of Things (IoT) and cloud platforms that further enhance efficiency through data integration and monitoring [11]; and predictive insights through AI and other forms of human-AI collaboration [78].

Given this increasing use of new and emerging technologies to address complex industry-wide challenges across the AEC sector, it is important to understand their implications for peoples' working conditions.

2.2 What Does Productivity Mean and Who Does it Serve?

In economic terms, productivity is defined as the ratio of outputs (e.g. goods, services, tasks) to inputs (e.g. time, money, labour, energy) [63]. In a broad sense, productivity refers to "how efficiently an economic activity converts the various inputs and resources it uses, into the final product or service which it produces"[91, p.11]. The outputs are normally a quantity (i.e. how much is produced), but can also be a quality (i.e. how well it was produced) [95]. HCI research typically mirrors this economic framing, focusing on how computing systems streamline task execution, reduce cognitive load and increase speed or accuracy [81].

However, the term productivity is both "widely used and often misunderstood" [95, p.35]. This is complicated further by the considerable difficulties in measuring productivity [73], which is particularly difficulty for knowledge work, where productivity becomes complex to calculate, due to the intangible nature of outputs and the complexity of non-standard work [23, 46].

In HCI, productivity is often invoked to justify the benefits of new technologies or to highlight their challenges. Reflecting the difficulty of assessing productivity of knowledge work, studies naturally rely on qualitative accounts [50, 88, 92, 102] or self-report questionnaires [12, 13, 44, 46, 64], often through open-ended questions such as "How efficient do you feel you were today in performing your work? "[60] or rating agreement to a statement such as "I regularly reach a high level of productivity"[64].

Other researchers have criticised technologies that stress efficiency and (intentionally or inadvertently) reinforce "busy work" [50, 68]. Instead of enjoying the benefits of productivity which should in theory offer workers additional non-work time and improved social outcomes, "[people] tend to fill that freed-up time with more tasks and activities in an attempt to accomplish more" [49, p.60]. Critics increasingly argue that contemporary technologies tend to privilege speed at the expense of other societal values and needs [6, 65]. For example, personal data-tracking devices framed as productivity tools can backfire, fuelling stress and an obsessive drive for constant improvement [56].

Ironically, some productivity tools have even added to the burden of what is perceived to be unproductive work, leading to the introduction of additional technologies to monitor screen-time [46], or mediate increased task switching between devices [44]. Recent Generative AI (GenAI) research shows how these innovations can add to the burden of work, redirecting effort away from the actual purpose of the work toward editing the generated output [77, 102, 106] or thinking through how to prompt the tool [22, 96]. As Bainbridge observed decades earlier [5], automation does not simply reduce workload, but instead creates new work to monitor and maintain the system. We now see similar patterns for GenAI [87], where advanced technologies pushes work to new areas that employees are largely unprepared for, changing the nature of the work and thereby undermining the promises of productivity.

As the prominent economist Jim Stanford [91] argues, productivity can serve the interests of both employers and employees, enhancing competitiveness while also enabling workers to enjoy improved wages, conditions, and job satisfaction in general when

[1]https://www.mckinsey.com/capabilities/operations/our-insights/the-construction-productivity-imperative

its benefits are equitably shared. In support, a growing body of research in HCI shows that workers often connect productivity more generally to job satisfaction or feelings of fulfilment [44, 64, 88]. Guillou et al. [33] go further, arguing for a shift toward Time Well Spent, where people evaluate productivity in terms of meaningfulness and satisfaction rather than throughput.

2.3 Deskilling Risks and Supporting Self-Efficacy through Embodied Work

In times of technological change, productivity and job satisfaction are often tied to the acquisition of new skills. Skill development may enhance individual capability, team collaboration and knowledge-sharing, and can be critical to collective productivity [3, 66]. Governments have therefore placed increasing emphasis on digital skills training, particularly in areas such as artificial intelligence, where shortages threaten national competitiveness [39].

The benefits of training are, however, unevenly distributed across the workforce. Training in emerging technologies often yields greater productivity gains for less skilled workers than for seasoned professionals [10]. Younger workers are generally more receptive to acquiring new skills, though this is not universal [43]. Older workers, in contrast, tend to perform better in training that builds on their existing expertise rather than training aimed at generating entirely new skills [76]. This points to a need for differentiated approaches to skill development that account for diverse career stages and learning preferences. Without such tailoring, training risks producing dissatisfaction by overwhelming workers or by leading to stagnation or deskilling.

HCI literature shows similar tensions. Studies have shown how various AI and extended reality tools can support novice learning and improve learning processes [31, 40]. Other research highlights the risks of deskilling, where AI development pipelines extract domain expertise, leaving workers with reduced authority in shaping outcomes [82] or alternatively encourage over-reliance, undermining confidence in their own judgment [86]. Similarly, Simkute et al. [87] draws parallels between emerging GenAI technologies and Bainbridge [5] original critique of automation, pointing out how these technologies push skilled workers into performing new roles that they are often ill-prepared for. Furthermore, persistent barriers, such as cost, time and uneven risks of displacement, further complicate re-skilling efforts [69, 76].

Innovation that is necessary for productivity growth [91], is often supported by both intellectual learning and how peoples engage with tools and materials using their physical bodies. Indeed, HCI has long recognised the role of the human body in shaping interactions. Seminal work on situated action [93], embodied interaction [21], and somaesthics [37] emphasise the inextricable link between mind, body, and environment, grounding meaning-making in practical activity. Even so-called "knowledge work" is never disembodied; it is grounded in physical artefacts, environments and routines [47].

HCI research in both trade and industrial domains supports the significance of embodied work. Barker and Jewitt's [7] ethnography of "filtering touch" illustrates how robots in dirty and dangerous work reconfigure sensory and affective relations, but still require embodied learning. Liu et al. [54] similarly argue that the transmission of traditional craft skills is inseparable from their embodied practice, highlighting how innovation and tradition are codependent in the physical enactment of making. Kernan Freire et al. [45] demonstrate how tacit knowledge is often invisible to its holders, requiring reflection and social exchange to become externalised. Mitterberger et al. [62] show how interactive robotic plastering systems can retain the aesthetic and technical potential of human-in-the-loop design, in contrast to trends toward full automation that risk excluding embodied craft potential. These accounts align with longer-standing critiques that neglecting embodied dimensions risks overlooking an important aspect of human work.

Importantly, embodied work also contributes to job satisfaction. The infamous IKEA effect [67] explains how people value outputs more highly when they have physically contributed to their creation. In HCI, this aligns with findings that mastery, tangible progress and physical involvement in tasks can enhance workers' sense of ownership and accomplishment [48]. Likewise, Sheehan and Le Dantec [85] caution that automation that strips away touch, physical contribution or self-sufficiency risks displacing the satisfaction workers derive from their labour. Meaningful work involves more than just the outcomes, but rather the embodied processes of achieving them.

Despite this, HCI has often treated knowledge work and physical work separately. Research about knowledge work tends to foreground reflection, cognitive coordination and information management [50, 64], while trade-focused research tends to addresses safety, tacit expertise, and craft learning [75, 103]. Yet work in the Architecture, Engineering, and Construction (AEC) industry tends to blurr this division: productivity is jointly constituted by knowledge workers (e.g. architects, engineers, project managers) and tradespeople (e.g. carpenters, surveyors, roofers). In the AEC industry, knowledge and embodied work are intertwined; design decisions need to be cognisant of material processes, while trades need an understanding of modern scheduling strategies in order to self-manage productivity.

3 ARTEFACT DESIGN PROCESS

This paper reports on part of larger project within a research centre investigating the design and use of emerging technologies in the AEC industry. The project's primary objective was to identify the issues and opportunities that emerging technologies create for working conditions in the AEC sector, with a particular focus on industrial relations and workforce training. A strength of this project is the involvement of a variety of stakeholders from regulatory bodies, commercial enterprises, educational institutions, and labour unions

We represent imaginings of new and emerging technologies through speculative design techniques. Taking inspiration from prior speculative design research, carried out by HCI researchers in collaboration with industry participants [52, 58, 80, 90], we undertook a three-stage design process to develop our set of speculative brochures. This consisted of: (1) mapping the socio-political system, (2) identifying real-world design tensions, and (3) establishing speculative artefacts. Twelve industry representatives (see Appendix A Figure 7) were engaged across all stages. These representatives come from diverse areas of the AEC industry, including regulatory authorities, training institutions, peak bodies, construction services, surveying consultancies, architecture, and prefabrication factories. The brochures were then shown to AEC participants in a series of semi-structured interviews, producing qualitative data that underpins this paper's contributions.

3.1 Stage 1: Understanding the Socio-political System

The AEC industry is a complex socio-technical system where the practices of employees and employers ultimately shape the buildings inhabited by end users. To explore this system, we conducted a desktop analysis of challenges in the AEC industry, producing the systems map, which can be found in the supplementary material. The map was validated and refined through feedback from industry representatives (Figure 7 in A).

Our process was guided by systems thinking [61], systemic design [41], and the Systems Mapping Academy toolkit[2]. Systems thinking sees issues within a socio-technical system as interconnected rather than isolated [61]. It highlights how feedback loops, whether reinforcing or balancing, influence system behaviour. In addition, interventions in one part of the system can create ripple effects, often producing unintended consequences elsewhere in the system [61].

This framing was critical for identifying how present challenges and technological interventions ripple out across the AEC system, and informed the design tensions presented in the next stage.

3.2 Stage 2: Identifying Real-world Design Tensions

In collaboration with our industry representatives (Figure 7, in A), we generated design tensions between interventions for present-day system challenges and aspirations for the future. Inputs for this stage included our systems map, future-based scenarios, and speculative sketches of emerging technologies. While these are not the primary focus of our analysis, they served as stepping stones toward the final speculative artefacts, and are therefore provided in the supplementary material for transparency.

The participants ideated preferred interventions to address challenges in the systems map and then reflected on scenarios and sketches as alternative futures. Using Affinity Mapping [55], we cross-examined the written outputs, comparing proposed interventions with desired futures. This design process revealed key tensions between addressing immediate system needs and envisioning long-term aspirations. These tensions included:

(1) **Productivity vs. Job Satisfaction:** The AEC industry faces pressure to improve productivity due to a shortage of skilled labour and high building costs. However, the push for greater efficiency may conflict with the industry's goal of creating fulfilling jobs that keep workers engaged.
(2) **Teaching New Skills vs. Upholding Traditional Skills:** Modern methods of construction (MMC) create new opportunities for a diverse workforce. However, there is a tension between embracing innovation and preserving traditional skills, often driven by concerns about the cost of adapting to change.
(3) **Speed of Technology Implementation vs. Safe Work and Quality Outputs:** There is a strong push to encourage innovation. However, this creates tension with the time required to uphold quality outputs and safe work practices, which are both essential for a healthy and desirable future.

These design tensions were used to structure the sliders **(Figure 2)** which in turn guided the creation of the speculative brochures in Stage 3.

3.3 Stage 3: Establishing the Speculative Artefacts

We created speculative brochures that illustrated three alternative futures, each highlighting the design tensions to different degrees, instantiated by the sliders depicted in **Figure 2**. Inspired by Oulasvirta and Hornbæk's counterfactual reasoning [70], this approach used tensions to theorise how design choices might shape real-world responses. Grounding the artefacts in the design tensions created in collaboration with industry stakeholders allowed us to probe how participants reacted to different weightings of competing values and critique how current technologies support, or undermine, desirable futures. The speculative artefacts also enabled a suspension of disbelief [4], helping us to probe the limits of participants' attitudes and beliefs.

The sliders **(Figure 2)**, based on the design tensions identified in Stage 2, were used to generate provocative ideas for the three sets of brochures, or *speculative probes*. For example, increased productivity, skill development, and speed of innovation logically go hand-in-hand. To instantiate more thought-provoking ideas, we paired unlikely sliders together. For instance, a strong emphasis on both productivity and traditional skills. We presented deliberately utopic rather than dystopic scenarios, with sliders trending toward more strongly prioritising the different values [20, 80]. By trending toward utopic futures we aimed to avoid overly obvious conversations about dystopias [79], instead prompting participants to think critically about the risks of technologies built with good intentions.

Using the sliders as a guide, we developed three alternative worlds, each represented by a brochure marketing a fictional service and describing three future workplace technologies. To ensure relevance, we created two versions per world (one for project managers and one for building inspectors) and refined them through feedback from five industry representatives **(Figure 3)**. We created these different versions so that participants with different backgrounds (e.g. regulatory or commercial) could adequately respond to the speculative probes. We provide a concise overview of each brochure below. For additional detail, the full brochures have been included in the supplementary material.

The speculative brochures follow Ringfort-Felner et al.'s [79] descriptive taxonomy for the quality of speculation. They are *fictional* artefacts that critically explore alternative realities for the architecture, engineering and construction industry. The tensions, instantiated by the brochures, encourage participants to think *critically* about prioritising certain values over others and how this challenges their assumptions about the way technology should be developed, taught, adopted, and regulated. They raise awareness of the *socio-political* dimensions of emerging technologies, bringing to mind how they might impact the feasibility of business, livelihood

[2] www.system-mapping.com

Figure 2: Sliders derived from the design tensions in Stage 2 were used to structure three sets of speculative brochures. These brochures were intended to present provocative and unexpected alternative futures, prompting deep reflection from participants.

of workers, and access to educational opportunities. The brochures are written such that the reader can plausibly *experience* the vision these services from alternate futures are trying to sell in simple and specific ways. Configuring the sliders so they felt challenging and not overly obvious helped us to create *thought-provoking* futures. Design stages 1 and 2 ensured the brochures' ideas were *grounded* in empirical data gathered from desktop research and in *participation* with AEC industry representatives.

3.3.1 Speculative Brochure Set 1: Job Satisfaction and Continuous Learning. These brochures **(Figure 4)** depict a future where work is deeply satisfying but less focused on output. Advocates emphasise freedom from pressure to learn or work faster, with personalised products that tailor learning to biometrics and lifestyle. In this world, "machines do the heavy lifting", inspections are transformed, and "learning happens on-site, exactly when you need it". The brochures state: "we prioritise safety and quality, never rushing transformation for the sake of speed".

The brochures promote three technologies: (1) AR sunglasses with a glare visor and safety-certified lenses, delivering "bite-sized learning modules" and real-time compliance tips; (2) the ParallelBand, which tracks biometrics and circadian rhythm to tailor learning while assuring data "never leaves the wrist"; and (3) a custom controller with long-range signal and high-resolution display, offering accessible AI and robotics management for all experience levels.

3.3.2 Speculative Brochure Set 2: Productivity and Mastering a Craft. These brochures **(Figure 5)** imagine a future where productivity eclipses job satisfaction. Services promise to "create more productive and resilient workplaces" by "removing barriers that slow teams down" and automating complex data collection. Workers are encouraged to "master [a] craft" like bricklaying or painting while AI manages project stress. The service emphasises rapid rollout, with little attention to safety or output quality.

The brochures promise to "support hands-on expertise" and "hone productivity through mastery" with three tools: (1) a hands-free bone conduction device for voice-activated guidance and building standards; (2) a 360° camera that records a project's lifespan, comparing plans to outcomes; and (3) a hybrid leveller that adds approvals and measurements directly to the digital twin.

3.3.3 Speculative Brochure Set 3: Everything Remote. These brochures **(Figure 6)** envision a future where productivity and job satisfaction are jointly prioritised. Services promise remote site management from home offices, freeing workers to focus on "complicated cases where [their] knowledge actually matters" and creating "rewarding leadership opportunities". Skill development is de-emphasised, with technical details handled automatically. Traditional trades are sidelined as workers manage projects through data-driven decision-making rather than on-site practice. Despite this shift, the service pledges rapid innovation "without sacrificing safety or quality".

The brochures promise a "seamless blend of life and work" with: (1) a smart fitness app that syncs with equipment to track wellness and reduce stress; (2) a stylish ear cuff for multitasking with audio updates, alerts, and reminders; and (3) an ergonomic chair with medical back support and controls for navigating high-resolution 3D site captures.

4 STUDY DESIGN

To facilitate critical discussion and reflection, semi-structured in-person interviews were carried out with participants working in the AEC industry. The interviews each lasted 90 minutes.

Key: Outline = Executive; Fill = Employee; Orange = Trade background; Purple = Knowledge work background

ID	Age bracket	Gender	Years of Industry Experience	Role	Experience
P1	45-54	Man	25	Business Executive, former Surveyor	Executive at a large building services company, as well as a construction data management and digital information initiative. He has a background in the regulatory space, having worked as surveyor issuing building permits.
P2	55-59	Man	40+	Business Executive, former Builder	Business leader of a large commercial construction company, with construction management experience across various large construction companies. Studied a building degree and grew up on construction sites while working for his Dad. Worked his way up from labouring onsite, to managing a large business.
P3	65-69	Man	40	Business Executive, former Mechanical Engineer	Director at a large building services company. He has a background in mechanical engineering, and a keen interest in technology innovation.
P4	35-39	Man	17	Project Manager, former Builder	Project manager for a commercial building company. He has prior trade experience in residential construction with a volumetric builder, went into administration then switched to commercial construction.
P5	25-29	Woman	3.5	Graduate Civil Engineer	Graduate project coordinator, specialising in 'structures'. She is a civil engineering graduate and worked as an undergrad in infrastructure, before moving into the building sector.
P6	55-59	Man	35	Surveyor and Business Leader	General manager for a consulting firm, where he specialises in building surveying. He has a background as a structural engineer then did a post graduate degree in building surveying. He also has experience in the regulatory space.
P7	50-54	Man	30	Property Development Director	Property development director and digital transformation advisor for private and public sectors. He has a background in construction and a keen interest in emerging technologies, particularly data management.
P8	18-24	Man	4	Construction Cadet, former Welder	Cadet at a construction company, currently studying a bachelor of construction management. He started working in construction as a welder, then decided to study building design. His Dad and Uncle work in bricklaying and plastering.
P9	40-44	Man	24	Plumbing Inspection Advisor, former Plumber	Plumbing inspection advisor for a regulatory body. Originally a plumber by trade, working on residential and industrial projects.
P10	60-64	Man	37	Union Representative	Union representative, working in their OH&S unit. He started labouring at 25, then did a Diploma of Occupational Health and Safety (OH&S), Graduate Diploma in Occupational Hazard Management and a PhD in OH&S.
P11	55-59	Man	40	Inspection Manager	Inspection team manager for a regulatory body. He trained as a plumber then started his own business with his Dad who was a gas fitter.
P12	60-64	Woman	40	Educator and Commercial Architect	Commercial architect and educator at a technical institute, interested in emerging technologies. She trained as an architect and went into commercial construction.
P13	25-29	Man	12	Educator and Carpenter	Carpentry educator at a technical institute. He trained as a carpenter and worked on residential buildings before moving into education after a workplace accident.
P14	55-59	Man	35	Surveyor and Business Leader	Registered building surveyor and building regulations expert at an industry peak body. Trained as an engineer and then worked as a building inspector and surveyor.
P15	35-39	Woman	13	Project Manager and Mechanical Engineer	Senior engineer at a large building services company where she also plays a role in their business development. She trained as a mechanical engineer and worked her way up from being a graduate to senior leader at her current company.
P16	18-24	Woman	6	Trainee Draftsperson	Draftsperson at a large building services company. Started as a trainee draftsperson at her current company, after finishing high school.
P17	40-44	Man	21	Work, Health and Safety Exec	Work, health and safety manager at a large building services company. Started with a project support role, working with project managers and site managers in his current company, then moved into working in safety and industrial relations.

Figure 3: We recruited 17 participants (4 women, 13 men) for our study. Although men were more represented, this reflects both our effort to balance roles and perspectives, as well as the broader gender imbalance in the AEC industry [26]. Participants brought diverse experiences spanning business, trades, regulation, design, engineering, project management, health and safety, and digital innovation, which we captured from their interviews and provide in the table. They represented a range of career stages and expertise. Their industry experience averaged 25 years, ranging from 3.5 to 40 years.

4.1 Procedure

4.1.1 Part 1: Introduction and Consent. Participants were welcomed, given an information pack and consent form, and invited to ask questions before providing written consent.

4.1.2 Part 2: Design Fiction Reflection and Discussion. Participants described their background, role, and prior experience with emerging technologies in the AEC industry. They were then shown the fictional brochures one at a time, reflecting on each before comparing them as a set. The researcher probed for elaboration relevant to the research questions, for additional details and full transparency the interview guide has been shared in the supplementary materials. Participants also rated each brochure on a 7-point Likert scale to indicate how strongly it prioritised the different tensions (1, weakly prioritises to 7, strongly prioritises). These ratings were not analysed quantitatively but used to contextualise participants' qualitative reflections. The participants were shown the brochures randomly each session to mitigate ordering bias in the conversations.

Figure 4: Brochure Set 1: Job Satisfaction and Continuous Learning: These brochures depict a future where learning new skills and job satisfaction are prioritised over traditional skills and productivity. Safety and quality also take precedence over rapid technology implementation. The supporting technologies depicted include: (1) AR safety glasses deliver on-site training, (2) the ParallelBand for biometric-based learning, and (3) a custom controller for accessible AI and robotics management.

Figure 5: Brochure Set 2: Productivity and Mastering a Craft: These brochures depict a future where traditional skills and productivity is prioritised over learning new skills and job satisfaction. Rapid technology implementation also takes precedence over safety and quality. The supporting technologies depicted include: (1) a bone conduction headset for voice-activated interaction with building standards, (2) a 360° camera for tracking project progress, and (3) a hybrid leveller that integrates measurements and approvals with a digital twin of the building.

Figure 6: Brochure Set 3: Everything Remote: These brochures depict a future where productivity and job satisfaction are prioritised over retaining traditional skills and learning new skills. Rapid technology implementation, safety and quality are equally important. The supporting technologies depicted include: (1) a fitness app for wellness and stress reduction, (2) an AI-powered ear cuff for project updates and reminders, and (3) an ergonomic chair with controls for remote robotics and site navigation.

4.1.3 Part 3: Questionnaire. Sessions concluded with a short demographic and technology experience questionnaire (results in Figure 8 in the appendix).

4.2 Data Analysis

All interviews were conducted by one researcher for consistency, audio-recorded, and transcribed in DoveTail[3]. Transcripts were analysed using Braun and Clarke's Thematic Analysis [19]. Two researchers led the coding, starting with a deductive framework from the research aims and adding inductive codes for emergent insights. The codes were iteratively refined, reviewed mid-way by the team, and consolidated into themes collaboratively to ensure alignment with the research objectives.

4.3 Participants

For the critical discussion and reflection on the speculative artefacts (the main data we report on in this paper), we recruited 17 industry participants (13 men and 4 women). **Figure 3** shows the background information on each participant, including their age bracket, gender and years of experience. These 17 participants were involved in the study, where as the co-design industry representatives listed in Figure 7 (Appendix A) were involved in designing the brochures used as stimuli in the study. Participants' familiarity with technology is shown in **Figure 8** (Appendix A), which lists the emerging technologies they self-reported using in their work and more generally, the emerging technologies used by their organisation. We aimed to recruit a diverse range of voices in different

[3]https://dovetail.com/

roles and career stages. Participants were recruited through the industry representatives' organisations **(see Figure 7, Appendix A)**. All participants were employed full-time and nominated by their respective organisations to take part in the study. We ensured that the interviews were conducted during work hours.

4.4 Position Statement

Our research team combines expertise in HCI and Industrial Relations. In line with reflexive thematic analysis [8], we treat our positions as analytic resources that informed how we interpreted the data. The first author conducted and coded all the interviews. She has experience working in IT and management consulting, where she previously worked on projects within the AEC industry that sought to improve the data sovereignty and sustainability practices. Identifying as woman, her experience working in male-dominated industries and growing up as an Australian immigrant has heightened her awareness of belonging and inclusion, informing her interpretation of participants' responses. The second and fifth authors have expertise in labour relations, worker rights, and organisational politics. Their perspectives directed our attention to how emerging technologies reconfigure power, including ongoing questioning of who productivity benefits and how it is defined across roles. We collaborated with representatives from five sponsoring organisations, a regulatory authority, industry peak body, real estate developer, building services company, and a training institution (disclosed in Figure 7, Appendix A). Their perspectives helped us to understand sector-specific practices and language. We engaged with these perspectives reflexively, recognising how they introduced particular institutional viewpoints into the research. The project was funded by an industry based Cooperative Research Centre (CRC), of which the sponsors are members. The CRC has independent research committee with formal procedures and structures which governed the research project. Our role as university researchers with HCI expertise brings traditions of academic practices and human-centred perspectives. Together, these positionalities informed the development of the themes and their interpretations.

5 FINDINGS

We identified two key themes that address our first research question (RQ1). Consistent with speculative design as a method for constructing questions rather than proposing solutions [30], each theme is presented as a provocation for future research in HCI. We engage in a critical discussion of these provocations in section 6.

5.1 Theme 1: Different Views on Productivity

The first theme captures perspectives on workplace productivity. Participants expressed a range of views that illustrate their complex relationship with technologies that enhance productivity. These perspectives go beyond participants equating productivity with efficiency. It captures how improved productivity can include a sense that technologies make work more satisfying. However, perhaps counter-intuitively participants expressed that improving productivity sometimes means slowing down to learn new technologies or investing in tasks that take more time. These ideas are captured by following subthemes:

5.1.1 ***There was a desire for technologies that make work easier or more efficient to focus on creating satisfying jobs.*** Indeed, P1 valued the satisfaction tied to efficient work, provided they are not "overloaded":

> *P1 "I'd be able to be more efficient [...] surely unless you're overloaded, surely that would be better job satisfaction'.'*

Similarly, participants from both employee and executive roles, as well as trade and knowledge work backgrounds (P9, P10, P15) voiced reluctance to focus on productivity as efficiency alone. In particular, P10 suggested that technologies should create better jobs, with productivity emerging as a by-product.

> *P10 "People just want better jobs, because if there're better jobs, they're more productive"*

As P15 further explained, making work *"less frustrating"* or more *"rewarding"* could be just as valuable as increasing the speed of completing the task.

> *P15 "I think, obviously, if you can get something done quicker, or eliminate something altogether so that you don't have to do it [that's good]. But also, maybe there's like an aspect [where], you may still have to do something, but it's somehow done in a more rewarding way, or it's less frustrating to do it [...] not necessarily quicker, but just easier."*

Technologies that automate or make tedious aspects of work more enjoyable were welcomed. Participants across different roles and skills exemplified mundane administrative tasks that distracted from more meaningful contributions (P1, P2, P5, P8, P16). For example, P5 described how automation could make a project more fun.

> *P5 "Getting caught doing all the other admin stuff, a lot of time prevents you from doing enough checks. So doing, having these running all the time and doing those checks for you is gonna, it will prioritise your quality, but it will, it will give you a better output, a fun product."*

Many participants (P1, P2, P4, P5, P6, P9, P10, P11, P12, P13, P15, P16) emphasised the opportunities for futuristic remote technologies to provide a healthier work-life balance. For example, P4 and P16 reflected on how remote work technologies could reduce overwork, support modern family expectations and promote inclusivity.

> *P4 "we've got families, we've got other priorities, [...] more about ourselves, our health, our family. You know, dropping kids off at school, that kind of stuff. So I'd be looking for anything that could sort of help me minimise [working overtime]."*

5.1.2 ***Participants recognised that, perhaps counter-intuitively, improved productivity also meant slowing down to learn new technologies or communicate with others.*** P6 points out the "chicken and egg" challenge of investing in learning new productivity tools, where they have trouble finding time to upskill or implement new productivity tools, especially when they are comfortable with the current way of doing things.

> P6 *"So it's a bit of a chicken and the egg type thing that, we're too busy to actually implement it, but if we implemented it it would make us less busy [...] So if we can actually dedicate some time to start adopting and implementing some of these, that will actually release more time [...] and so I think it will be a snowball effect if you can invest that time and effort [...] But it is hard work because you're busy doing what you're doing, [...] you go to your comfort zone of things and ways you know how to do things and then as soon as you start stepping out of that to these new areas, you're not as confident or, committed quite often."*

While autonomous robotics and technologies that support remote work were seen as offering certain individual benefits:

> P2 *"[I can probably do] 12 hours worth of work in 6 hours [at home because] I don't have people coming in and asking me questions [...] or someone arrives at reception and wants to catch up with someone to talk about a job or whatever it is. All those distractions are taken away and it makes life a lot easier."*

However, participants also acknowledged the limits of focusing only on individual efficiency. As P16 admitted, the desire for uninterrupted solo work can conflict with the collaborative demands of the industry.

> P16 *"I am guilty sometimes. I just want to have an easy day at work. I just want to model and that's all I want to do. I just want to work through, you know, that particular task, but it's not like that every single day — there are days where you have to collaborate."*

This tension between individual efficiency and "slowing down" to communicate with others is especially salient in the AEC industry, where specialised services (e.g. design, engineering, project management, construction) must ultimately coordinate to produce a shared, tangible output: the completed building:

> P15 *"I suppose sometimes it's not so much about my part in that, but a downstream part in that as well. Perhaps it's doing something that doesn't directly benefit me, but I know is making the process for someone else downstream easier. [...] It's like a productivity for them, might not be for me, but that tech is still obviously beneficial if it's helping out down the road.*

Across both subthemes, participants stressed that "productivity" cannot be understood as speed or efficiency alone. They wanted technologies that make work easier, less frustrating and more meaningful. Perhaps by reducing administrative burdens and supporting healthier work-life balance, while also recognising that genuine productivity sometimes requires slowing down to learn new tools or coordinate with others to support downstream collaborators. These insights reframe productivity as something created through satisfying and sustainable ways of working rather than simply doing tasks faster.

Provocation 1: How could productivity be reframed to prioritise experiential aspects, beyond speed, and efficiency?

5.2 Theme 2: Connecting and Applying Different Types of Knowledge

A defining feature of AEC work is creating tangible structures that people can see, inhabit, and experience. In responding to the brochures' alternative futures, participants emphasised that this connection to making something "real" was what attracted them to the industry. Producing a physical output requires embodied knowledge about materials, developed through hands, tools, and bodies interacting in space. Participants discussed how emerging technologies may mediate this bodily connection with the external world, either enhancing or diminishing the satisfaction of contributing to the built environment and the chance to apply their learnt skills. These ideas are captured in the following subthemes:

5.2.1 ***Technological automation appears at odds with peoples' pride in applying learnt embodied skills.*** Most participants (P1, P2, P3, P5, P7, P8, P13, P15) agree that seeing the final physical building is a major source of satisfaction in their work. This is true of people who have experience in a physical trade, like P13, a carpenter turned trainer.

> P13 *"I'll take my wife every single time I go for a drive around a certain way because I'm like, I built that house down there [...] it's a satisfaction of going, [...] I built that one, I built that one, I built that one. And I feel like the apprentices [...] they all do the exact same thing. Like they're quite proud of their work [...] they've all got folders on their phone of everything they've done in their whole career so far."*

As well as those with knowledge work backgrounds like P7 and P15:

> P7 *"[The craft] is more romantic [. . .] I can still smell wood being cut and I don't know, the smell of fresh concrete [. . .] symbolises a space and a place for me where this [remote hub with robotics] doesn't feel like [. . .] you're gonna get close to it."*
>
> P15 *"So, although I'm not a hands-on person, I still really get a lot of satisfaction from that physical side of [projects]."*

This affinity with the physical output is the key reason why many participants joined the AEC industry in the first place. Similarly, Participants like P8 and P13, with trade backgrounds, describe a sense of pride in seeing their embodied contribution to the construction of the building. As a result, the possibility of outsourcing the skills that they have invested in to a robot would not feel satisfying.

> P8 *"I'll drive past the job and I've got my girlfriend in the car and I go "oh yeah, I remember working here, I did this, I did that," [...] it's more rewarding [than] if you say, "oh yeah, a robot did that."*
>
> P13 *"[. . .] I don't think I would get much job satisfaction with it, [. . .] [it] feels like I'm setting the machine up to go. I don't know, it almost feels like if you're making a cake or something, if you buy a cake mix in a box,*

> *it feels like the work's already done for you. But if you do it from scratch, you have more satisfaction from it."*

This desire to maintain embodied skills juxtaposes the goal of engineering systems to eliminate human variation. P14 explains how, in modern methods of construction that engage in human-robot interaction, skilled carpenters can introduce errors into the engineered system if they follow their trade-based intuition rather than the programmed-based instructions.

> *P14 "If there's a virus in the system [...] call it the carpenter who thinks he knows better than the system, then unless we catch it and stop it, then that's always going to end up being a problem [...] the computer actually will spit it out and say you need to put stud there, stud there, stud there, there, stud there, stud there [...] if you've got somebody who's adjusting stuff it pushes it out."*

However, P13 highlights how the tacit knowledge gained through training as a carpenter contributes to smoother building projects overall. Specifically, carpenters' attention to detail, such as accounting for the natural bows in timber, ensures that parts arriving on site are easier to assemble for the team.

> *P13 "For an example, like when you learn to frame walls on apprentice, you'll have your bows in your stud and your bows if you're doing an external wall and standing up that way, your bows will always [go a certain way] [...] Where if it's a prefab factory, they're not checking for bows or anything like that, they don't care, they just want the product out [...] They're just chucking studs in, so it's go, go, go."*

Notably, many employees across both trade and knowledge work (P5, P8, P10, P12, P13) echoed this desire for their years of training and applied expertise to be valued, suggesting points of commonality across the AEC ecosystem.

> *P10 "[businesses] haven't utilised the knowledge and the skill and the experience, which is sitting dormant on the shop floor, [...] They're not getting involved and then people are just feeling, you know, disenfranchised, disheartened, [...] they realise they've got no control over their work life, "What's the point?""*

5.2.2 ***People expressed how their body plays an important role in learning.*** A common suggestion for supporting physical skills and traditional knowledge is to retrain workers into different roles. However, our results showed some fundamental challenges with this kind of upskilling and transfer of knowledge. For example, P10 explained the socio-political challenges, where some people go into a trade because they were not afforded the opportunity to develop certain literacy and numeric skills.

> *P10 "Our training unit, I think they put 10,000 people through a year and I think it's, it's a 60% or 80%, it's a staggering amount of people who need some type of assistance in numeracy and literacy when they're looking at a brochure or a manual, you know, how to read that, [the help required is] quite high."*

The discrepancy between the intended new skills and existing worker proficiencies creates significant challenges. If opportunities for reskilling in robotics or modern methods of construction is reliant on a certain method of teaching or mode of information that does not make learning accessible, then different approaches need to be considered. P13 emphasised a preference for kinaesthetic, hands-on learning, contrasting it with abstract, text-based instruction.

> *P13 "Most of the kinaesthetic or the tradie blokes [...] if we watch a video of someone else doing it once, we seem to understand it better than reading a book or something like that. But if you've got the AR glasses showing you as you're doing it, I think it would be great."*

There are some opportunities for technology to support rather than automate embodied work. For example, P17 described a desired future where augmented reality and AI technologies provide a more proactive and physical approach to safety reminders.

> *P17 "I don't see [technologies] being a risk for people that use them every single day. There's a lot of our team that do use them every day [...] whereas people that use them rarely need to do them 5 yearly just to confirm [they're compliant]. They're probably the ones who need more training, and ideally you'd use VR to be able to do that training without going to an expensive classroom. You go and actually take it out to the site and they can do it on the site they put that on and then confirm that they know how to do certain checks and how to do certain things."*

Alternatively, the speculative brochures prompted participants to imagine using a combination of GenAI and augmented reality (AR) to aid workers on the building site. For most participants across the system (P4, P5, P6, P7, P8, P9, P10, P11, P13, P15, P17), this was an unsettling idea. In their eyes, this technology could enable anyone (with little or no experience) to follow step-by-step guidance and achieve results previously reserved for skilled trades. P4 worried that relying on AI and robotics could normalise having unskilled workers on-site, undermining traditional apprenticeship models and the trust placed in passing down expertise from experienced professionals.

> *P4 "That kind of worries me a little bit in terms of people should know their task before they get there [...] I shouldn't be teaching them how to do their job while they're there. So that does genuinely worry me a little bit [...] the apprentice shouldn't be sitting there learning off AI or a robot, the apprenticeship you learn off someone [who has a] huge amount of skill in the industry."*

Some junior participants questioned the logic of learning certain skills in the first place if "AI can do it".

> *P8 "Sometimes I think AI probably removes learning. That's very contradicting. But If AI can do it, what's the point of learning it? "*

Yet other experienced participants, who primarily act as knowledge workers in the system, warn against "shortcut culture"'. In P15's perspective, relying on AI could lead junior staff to miss important contextual understanding, learnt through directly engaging with the construction standards in full.

> P15 *"One of the things we find at the moment is the younger generation coming through are far, far more inclined to [...] just go straight to the answer that they're looking for. [...] which is actually a little bit of a concern for the more senior people, because standards are a [...] weirdly written document, right? And quite often you find that if you take a little piece without reading the context, it maybe doesn't actually give you the same answer or the same outcome. So we're [...] constantly encouraging people, as boring as it is, you need to go and [...] understand the document as a tool before you can start taking pieces out of it.*

Similarly organisational leaders with a trade background such as P1, believe certain skills in the AEC industry require time invested in people going on site and getting close to the context a skill is carried out in.

> P1 *"A set of experiences over the time with doing all these inspections, going to site and picking up these skills that you inherently don't get from a textbook. So, the, there's a difference, in my role as teaching, graduates coming through, you can learn as much as you can learn from a textbook, but learning from on the job and getting out there and seeing it and seeing what it does is quite valuable."*

Throughout these subthemes, participants across all roles and skill backgrounds, consistently emphasised that AEC work relies on embodied, hands-on knowledge and the satisfaction of contributing to something physically real. While emerging technologies offer opportunities to support training and on-site decision-making, participants worried that excessive automation or over reliance on AI could undermine the development of skills across knowledge work and trades that both require embodied training.

Provocation 2: What would systems look like if they were designed for the intersection of cognitive and embodied skills development?

6 IMPLICATIONS AND DISCUSSION

> *"To innovate the vessel was already to innovate the shipwreck [...] each period of technological development, with its instruments and machines, brings its share of specialised accidents, thus revealing 'en negatif' the scope of scientific thought."*
> — **Paul Virilio [99]**

Based on the provocations that arise from the themes above, and in response to (RQ2), we propose directions for future research, which include both an optimistic solution and *en negatif* perspective [99]. While it is important to direct our efforts away from possible dystopic futures, an exploitative future under the guise of a utopia is no better. As proposed by Lin and Lindtner [51], we do not shy away from the negative possibilities of technological innovation. Rather, we accept that with any new invention or way of being, there are potential negative outcomes that demand consideration.

6.1 Productivity Research that Values More than Efficiency

Provocation 1: How could productivity be reframed to prioritise experiential aspects, beyond speed, and efficiency?

Our findings continue to challenge assumptions that productivity primarily serves to encourage busyness, speed, or increased output [35, 49, 50]. Although participants cautioned against rising workloads due to technologies framed as boosting productivity, some talked about experiencing satisfaction when tasks became safer, less frustrating or beneficial to others downstream. These accounts corroborate HCI research with knowledge workers, that links perceived productivity to positive experiential factors, such as job satisfaction [33, 44, 46] and self-efficacy [48].

While HCI research focusing on knowledge work has establish a link between productivity and job satisfaction [33, 46, 48], to the best of our knowledge, there are few studies that critically examine this link. Kim et al. [46] note that the "emotional state" of workers affect productivity, yet do not elaborate on this link. Guillou et al. [33] go further to suggest using the metric "time well spent", illustrating how "the way people feel" and "satisfaction" is an element of this metric. Kaur et al. [44] measure the emotional state of participants, relying on organisational behaviour studies on the "happy-productive worker hypothesis" that states happier workers are more productive [97]. We call to mind Frøkjær et al.'s [28] influential paper that examines usability measures, arguing that "efficiency, effectiveness, and satisfaction should be considered independent aspects of usability" [28, p.351]. We suggest that, given the link our results emphasises between job satisfaction and productivity across both knowledge work and trade skills, there would be significant value in a similar study being carried out to critically examine these links and measures of productivity in HCI.

Beyond job satisfaction, participants' reflections highlighted a need to slow down to learn or communicate with others, which supports productivity not only for themselves as individuals but for their workplace as a whole. This supports emerging arguments that, productivity is achieved in the first place by investing in time to learn and innovate [91]. However, as discussed in section 5.1.2, participants found that innovation is often most needed at the very moments when workers are too busy to step back, reflect and imagine doing things differently. Some participants noted that investing time in mastering new skills can feel counter-intuitive if it temporarily slows down output, even though such learning may ultimately have long-term benefits.

While slow technology has traditionally been positioned in opposition to efficiency and productivity [68], our findings suggest workers perceive it as not needing to be the case. Participants across both knowledge and trade roles were generally supportive of productivity, but acknowledged the importance of reflection to improve productivity and job satisfaction. Rather than positioning productivity and reflection as opposites, slow technology could be used to inspire new workplace tools and interactions that deliberately nudge people to pause, reflect and learn as part of their everyday practice. In design traditions more broadly, reflective design aims to bring "unconscious aspects of experience to conscious awareness, thereby making them available for conscious choice" [84, p.50]. For example, Xu et al. [102] recently demonstrated how supporting reflection through AI work tools can encourage critical thinking. Taking this a step further, future technologies might oscillate between slowing down to learn and grow, and providing a "tailwind" that allows people to enjoy a flow-state of applying their hard-won expertise. For example, Tankelevitch and Kewenig et al. [96] suggest that the demands of interacting with GenAI systems can be addressed by (1) providing metacognitive supports that help users reflect on their own processes, or (2) reducing metacognitive load by offering clearer explainability and customisability. We highlight a design opportunity to deliberately pace technologies so that they oscillate between supporting deep metacognitive reflection and reducing mental load. In practice, this could mean systems that, at times, slow people down to encourage critical awareness of their work [102], or to a more frictionless flow state.

In adopting Virilio's *en negatif* perspective [99], we encourage researchers to think critically about what it means to focus design goals on job satisfaction and embed the idea of reflective design and slow productivity [65] into workplace technologies. For example, redesigning technologies with productivity as a means to do more satisfying work might be an exploitative pursuit if workers are not given autonomy over this decision. Sara Ahmed [1] recounts in *The Promise of Happiness* the "long histories of scholarship and activism which expose the unhappy effects of happiness, teaching us how happiness is used to redescribe social norms as social goods" [1, p.12]. While the pursuit of ideals like job satisfaction may appear well-intentioned, researchers must ask who is defining satisfaction. In this case, we as designers are stating that this satisfaction is something other than the social pressures of adding value by cramming as many outputs into the day as possible. However, this reframe does not alter the underlying power dynamics between employer and employee. Ultimately, employers, even alongside employees, are still poised to reap rewards of any improved productivity. Here, the ethics of nudge theory [36] become particularly salient. Efforts to 'nudge' workers toward reflection or satisfaction may, without safeguards, become coercive strategies that instrumentalise wellbeing in the service of monetary gain [36]. This has an eerie ring of the 'happy slave', a politics that demands others live according to a wish [1], perhaps instated by employers or even by us as designers.

To reframe productivity around experiential qualities rather than efficiency alone, workers must retain autonomy over how the benefits of technology are realised. Without this autonomy, even well-intentioned efforts to support satisfaction risk becoming coercive. For example, prescribing how wellbeing should be achieved and instrumentalising it toward organisational output. Kaur et al.'s [44] AI-powered break-encouragement system demonstrates this tension in aiming to "keep workers happy so that they stay productive", whereas participants in their study wanted to "improve productivity so that work becomes safer, easier, and more enjoyable". Our findings show this dichotomy: P1, speaking from an executive perspective, assumed that increased speed or output in "doing two projects instead of one" would naturally produce satisfaction, whereas P10 imagined a future in which meaningful, satisfying work produces productivity as a by-product.

These opposing orientations have the potential to encourage fundamentally different designs. In Kaur et al.'s system, the break-recommendation feature proposes future tools to "avoid disrupting people's focused work times" [44, p.9] stressing the need to time an "opportune" moment to take a break, which they frame as making people happier. However, if designed from P10's perspective, perhaps the authors might have emphasised how their tool could help workers stop "hours turn[ing] to blurs without something to break them up" [44, p.9], perhaps suggesting how workers can design breaks or self-reflections in their day so that they feel more present and autonomously improve their working conditions. Based on our participants' aspirations for the future, we urge HCI researchers to examine whether technologies optimised for organisational goals genuinely achieve the same ends as those shaped around employees' desires. Designing for one is not equivalent to designing for the other, and conflating the two risks reproducing the very productivity pressures such technologies seek to address.

6.2 The Intersect of Cognitive and Embodied Work

Provocation 2: What would systems look like if they were designed to focus on the intersection of cognitive and embodied knowledge?

Our findings showed that both participants with a knowledge work and trade background felt a strong connection to the tangible outputs of their work, whether through hands-on trades or more theoretical applications of knowledge. Satisfaction was closely tied to feelings of self-efficacy and ownership over what they produced. In response to the speculative brochures, participants frequently expressed concern that these imagined futures abstracted human bodies away from the physical outputs of work.

Several participants with trade expertise worried about being pushed into administrative or roles where they supervise robots doing the skill they once learnt, distancing them from the tangible outputs of their labour. While such views might be dismissed as "resistance to change" or nostalgia for traditional skills [32], this interpretation overlooks the deep human connection between effort and outcome [67], especially when that outcome is a physical artefact like a house. Beyond earning a wage, participants expressed a fundamental desire to remain connected to the *making* process, and to see the tangible outcome of their skill development. They feared being reduced to supervising robots performing tasks less skilfully than they could themselves, a scenario they described as dissatisfying, disenfranchising, and devaluing of their expertise.

The promise of "new jobs" in an automated future did not inspire enthusiasm. Participants believed that these new jobs were likely to demand extensive retraining (that they had little time to pursue), relied on levels of computer literacy (that made the retraining inaccessible), or represented work that did not align with their interests or expertise in embodied work. According to participants with a trade background (e.g. P8, P10, or p12), training approaches currently applied in the industry often default to text-heavy, abstract formats that privilege knowledge work styles of learning. Instead they emphasised the value of tactile, spatial and kinaesthetic forms of mastery. Furthermore, participants from a knowledge worker background (e.g. P15 or P5) also expressed a desire for knowledge to be situated out of the computer and in the world. Based on these desires, we suggest there is opportunity for HCI research to represent abstract concepts like work scheduling in physical spaces. Similar to Henning and Hornbæk's system [74], which uses augmented reality to move abstract calculations into the 'physical world', future systems might use augmented reality to overlay the next stages of a building project into a physical space, communicating dependencies between different elements on a building site in a more tangible way.

HCI has a strong recognition of how the human body is crucial in both trade [7] and knowledge work [47]. However, the field has perhaps been guilty of either focusing on knowledge or trade work in separation, without a consideration of how these skill sets are symbiotic in many industries. Much of the discourse on GenAI has centred on knowledge work, for example, by optimising remote team meetings [14, 83, 98] or writing text-based materials or other knowledge worker outputs [48, 101, 104]. Our findings highlight a need for greater consideration of the overlap between cognitive and physical forms of work; where industries like AEC, require knowledge workers (e.g. architects, engineers or project managers) to understand how physical materials are constructed and tradespeople (e.g. plumbers, roofers and electricians) need to understand how modern modes of scheduling works to autonomously negotiate how their work ties into a larger project. A combination of augmented reality (AR) and GenAI may help to bridge these modes of work [94]. However, our participants also voiced concerns that entirely remote solutions could compromise safety and erode the sense of place that anchors embodied skill; like the evocative 'smell of wood' that affirms the reality of making. Future technologies should respect both cognitive and tangible practices, with the recognition that productivity should recognise that embodied expertise develops slowly, and that time for learning is itself a crucial part of productive work.

However, from an *en negatif* perspective, further integrating AR and AI into workplaces with the wrong goals can risk sidelining the embodied knowledge that has long underpinned expertise in the AEC industry. On-site training through headsets can create the illusion that complex skills can be acquired by simply following prompts, reducing learning to surface-level interactions rather than the tacit, embodied practices developed through mentorship and repetition. Indeed, participants feared this shift might threaten professional identity and also weaken pathways for transmitting craft knowledge between generations. The push to automate, accelerated by global pressures such as housing crises, compounds this risk: rather than respecting workers' accumulated expertise, technological change often seeks to remove humans altogether, treating them as obstacles to efficiency. Participants themselves noted this trend, with one comparing the engineering tradition to removing a "virus" from a system. However, such approaches fall prey to the false promise of artificial productivity gains. As Bainbridge's "irony of automation" [5] reminds us, attempts to remove human effort merely displace it elsewhere, often in less supported, more precarious roles. Participants echoed this, observing that speculative technologies would still demand oversight and coordination, a finding echoed in contemporary analyses of GenAI [87]. What emerges is not greater productivity, but a redistribution of labour that undervalues embodied knowledge and leaves workers unprepared for new roles.

Based on our findings, we invite HCI researchers to consider how productivity might improve if technologies are designed to build on, rather than bypass, the embodied skills workers already possess. P14's description of embodied intuition being treated as a "system virus" exposes a deeper issue where AI and AR systems implicitly assume that expert deviation is noise to be corrected rather than knowledge to be understood. Our findings suggest that, instead of enforcing behavioural conformity, future systems should be designed to *interpret unexpected actions as potentially meaningful expressions of tacit expertise*, particularly in domains where skilled, embodied labour is important. This could be achieved by designing for *Interpretive Flexibility*, in which systems treat deviations from predicted behaviour as candidate signals of situated knowledge rather than as errors. Unexpected human corrections, can instead be provisionally recognised as *expert cues* to consider and integrate into the broader system, especially when performed by experienced workers. Such systems will require a careful consideration of expert and novice definitions. In these framings, expert intuition is not a "virus" to be removed, but a source of value that technical systems must learn to recognise and build upon.

7 LIMITATIONS AND FUTURE WORK

Our study focused on the Architecture, Engineering, and Construction (AEC) industry. This context enabled us to investigate an under-examined space where cognitive and embodied work intersect, offering HCI researchers valuable insight into a large and globally significant workforce. However, the specific organisational structures and regulatory pressures of the AEC sector may limit generalisability to other domains. We sought to mitigate this by focusing on transferable aspects of work, such as coordination, craft expertise, and the creation of tangible outputs. Future research should consider how differences in project requirements, skill compositions, and power relations across industries might influence the applicability of these findings.

Our sample of 17 participants aligns with similar qualitative and speculative HCI studies [16, 80]. This approach provides rich qualitative insight into workers' subjective aspirations and concerns for future technologies. These insights can guide subsequent studies employing more quantitative methods. We acknowledge that the in-depth nature of our interviews and the time required to complete these, meant that not every role in the AEC sector could be represented. However, we provide detailed participant backgrounds to illustrate the diversity and complexity of their cross-disciplinary experiences.

A key strength of the study was engaging a wide range of industry experts over the project's year-long duration. However, not all participants could be involved at every stage. Instead, we maintained group of industry representatives (**??**) who guided the design process and informed the final speculative brochures, while later participants (selected to ensure role diversity across surveying, site trades, engineering, architecture, and management) responded to the probes rather than co-creating them. This discontinuity may have influenced how tensions were framed, although we believe the diversity of perspectives ultimately strengthened the analysis and revealed how different roles and generations respond to the ideas informed through our co-design workshops.

The sliders used to inform our speculative brochures were designed to produce futures that felt uncanny yet grounded, aligned with speculative design best practices [4, 80]. These probes intentionally leaned toward utopian futures to encourage critical reflection. We intentionally positioned the sliders to introduce uncanny futures (e.g. the unlikely pairing of improved productivity and retention of traditional skills). While this approach encouraged critique, the emphasis on optimistic scenarios may have limited exploration of more dystopian perspectives.

Finally, we used the sliders as a design tool to generate artefacts that visualised the tension and co-existence of seemingly opposing values (e.g. productivity and job satisfaction, or productivity and traditional skills). Even though this approach helped challenge assumptions suggesting these values are inherently in conflict, it may also risk implying zero-sum trade-offs between the values. Future research should examine the methodological implications of using such sliders in speculative design, particularly their capacity to balance clarity and complexity.

8 CONCLUSION

Productivity cannot be understood merely as a ratio of outputs to inputs. By engaging AEC workers with speculative design artefacts, we share how productivity is lived, negotiated and contested across diverse roles. These reflections remind us that technologies promising to "save time" are never neutral. They redistribute effort, redefine expertise, and recalibrate the value of human contribution.

Through provocations produced by the findings we critically engage with three opportunities for HCI research, providing both *en negatif* reflection and positive direction forward. First, we show how reframing productivity as a pathway to job satisfaction, not simply as output maximisation, can inspire alternative directions for technology design. Second, we demonstrate the importance of foregrounding embodied work, cautioning against technological trajectories that treat physical expertise as inefficiency to be eliminated.

More broadly, this research contributes to a growing body of HCI scholarship that critiques the taken-for-granted logics of productivity, seeking to reclaim it in the service of social as well as economic outcomes. As researchers and designers, we are faced with a choice to continue pursuing ever-greater efficiencies or to cultivate futures where productivity is a means to more fulfilling, sustainable, and dignified work.

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A APPENDIX

Key: Outline = Executive | Fill = Employee | Orange = Trade background | Purple = Knowledge work background | Green = Mixture Knowledge Work and Trades

ID	Age bracket	Gender	Years of Industry Experience	Role	Experience
IR1	65+	Man	25	Director for Applied Research and Innovation	Dean faculty of Building Construction and Engineering (15 years), research including building and construction (10 years).
IR2	40-44	Man	21	Digital Strategic Partnerships Exec	Structural Engineer on multiple building types, moving to a supplier of mass timber products as design lead. Spent 10 years in a developer building mass timber buildings, and more recently in design automation software.
IR3	45-49	Man	25	Research Development and Education Manager and Architect	Specialises in the manufacture and design of buildings made offsite using advanced methods of manufacturing. This came after spending the first 15 years finding construction generally inefficient and cumbersome.
IR4	50-54	Woman	10	Manager, Research and Evaluation	Working in a regulatory agency, managing licensing and registration functions, and managing the research program.
IR5	60-64	Man	25	Senior Technical Advisor - Sustainable and Future Built Environments	Sustainable Building Advisor for a Peak Body for the past 20 years and worked on building and construction related projects and research for the last 24 years. Extensive experience in education and training has informed the development of nationally recognised sustainable construction training programs. Extensive experience working with regulator organisations.
IR6	Prefer not to say	Prefer not to say	9+	Chief Analyst	Worked 9+ years for a regulator as their chief analyst.
IR7	30-34	Man	11	Prefabrication Leader	7 years as an engineering then remaining time in current role.
IR8	30-34	Man	11	Business Analyst	Prefab Manufacturing for mostly residential Construction.
IR9	30-34	Man	14	National Engineering Manager	Previously worked as a consulting structural engineer in the buildings space. Now have moved into a engineering lead role at BlueScope steel in manufacturing of composite metal decking.
IR10	50-54	Man	35	Consultant	Engineering and construction, experience working for large construction companies.
IR11	65-69	Man	40	Director of Innovation	Director at a large building services company with a background in mechanical engineering
IR12	55-59	Man	35	Geral Manager (surveying)	General manager for a consulting firm, specialised in building surveying.

Figure 7: Co-design Industry Representative Backgrounds

ID	Age bracket	Gender	Years of Industry Experience	Emerging technologies they personally use for their work	Frequency of Use	Emerging technologies their organisation uses more generally	Frequency of Use
P1	45-54	Man	25	Virtual reality (VR) headset, Digital twins, BIM tools (e.g. Revit), Artificial intelligence (AI)	BIM, AI - weekly Others - Yearly	Augmented reality (AR) on my phone or tablet, Augmented reality (AR) headset, Virtual reality (VR) headset, Digital twins,BIM tools (e.g. Revit), Drones, Artificial intelligence (AI).	BIM, AI - weekly, Others - Yearly.
P2	55-59	Man	40+	BIM tools (e.g. Revit), Offsite robotics, Drones, Artificial intelligence (AI)	Irregular	Virtual reality (VR) headset, BIM tools (e.g. Revit), Offsite robotics, Onsite robotics, Drones, Artificial intelligence (AI).	Frequently.
P3	65-69	Man	40	Virtual reality (VR) headset, Blockchain, Digital twins, BIM tools (e.g. Revit), Drones, Artificial intelligence (AI).	In my role I have been instrumental in introducing and or piloting these technologies for our business rather than using them personally.	Augmented reality (AR) headset, Digital twins, BIM tools (e.g. Revit), Artificial intelligence (AI).	AR was trialed approximately 8-10 years ago for various applications. These trials did not result in any enduring applications. We have plans to revisit the technology now that it has developed further. Digital twins, BIM tools and AI are in multiple continuous applications. BIM is central to our business's predominant workflow.
P4	35-39	Man	17	BIM tools (e.g. Revit), Offsite robotics, Drones, Artificial intelligence (AI).	Once per week.	BIM tools (e.g. Revit),Offsite robotics, Drones, Artificial intelligence (AI).	5 days per week.
P5	25-29	Woman	3.5	Augmented reality (AR) on my phone or tablet, Virtual reality (VR) headset, BIM tools (e.g. Revit), Drones, Artificial intelligence (AI).	AI and BIM I use daily. Others are every few months.	Augmented reality (AR) on my phone or tablet,Virtual reality (VR) headset, BIM tools (e.g. Revit), Onsite robotics, Drones, Artificial intelligence (AI).	AI, drones, BIM are used daily. Others are every few months.
P6	55-59	Man	35	Drones, Artificial intelligence (AI).	Rarely.	BIM tools (e.g. Revit), Artificial intelligence (AI).	Weekly.
P7	50-54	Man	30	Augmented reality (AR) on my phone or tablet, Augmented reality (AR) headset, Virtual reality (VR) headset, Blockchain, Digital twins, BIM tools (e.g. Revit), Artificial intelligence (AI).	Rarely.	Digital twins, BIM tools (e.g. Revit).	Not at the moment.
P8	18-24	Man	4	BIM tools (e.g. Revit), Artificial intelligence (AI).	Close to everyday.	Blockchain, BIM tools (e.g. Revit), Drones, Artificial intelligence (AI).	Weekly.
P9	40-44	Man	24	Artificial intelligence (AI).	Daily.	Drones, Artificial intelligence (AI).	Daily.
P10	60-64	Man	37	Augmented reality (AR) on my phone or tablet.	Every day.	Augmented reality (AR) on my phone or tablet.	Every day.
P11	55-59	Man	40	Drones, Artificial intelligence (AI).	Not often.	Drones, Artificial intelligence (AI).	Not often.
P12	60-64	Woman	40	Virtual reality (VR) headset, BIM tools (e.g. Revit), Artificial intelligence (AI).	Revit regularly as part of my design practice, AI on a daily basis.	Augmented reality (AR) headset, Virtual reality (VR) headset, BIM tools (e.g. Revit), Other (please specify).	On a daily basis.
P13	25-29	Man	12	Artificial intelligence (AI).	Only at professional development.	Augmented reality (AR) on my phone or tablet, Virtual reality (VR) headset.	Often for every class in Cert IV in Building and Construction.
P14	55-59	Man	35	None	N/A	Virtual reality (VR) headset, Digital twins.	Regularly.
P15	35-39	Woman	13	BIM tools (e.g. Revit), Artificial intelligence (AI).	Limited. Occasional experimentation with what it can do to help my tasks.	Digital twins, BIM tools (e.g. Revit), Artificial intelligence (AI).	BIM is used extensively. I'm not aware of much use of the others, still in the AI experimentation phase.
P16	18-24	Woman	6	Digital twins, BIM tools (e.g. Revit).	Everyday.	Augmented reality (AR) on my phone or tablet,Virtual reality (VR) headset, Digital twins,BIM tools (e.g. Revit), Other (Trimble and laser scanners).	1-2 a week.
P17	40-44	Man	21	Virtual reality (VR) headset, BIM tools (e.g. Revit), Drones, Artificial intelligence (AI).	Weekly.	Virtual reality (VR) headset, Digital twins,BIM tools (e.g. Revit), Offsite robotics,Onsite robotics, Drones, Artificial intelligence (AI).	Daily.

Figure 8: Study participants' self-reported personal use of emerging technologies, and more broadly the use of emerging technologies by others in their organisation.