Frontline Worker Readiness for Robotics in Construction: Reframing Integration through an Explanatory Case Study

Introduction

The integration of robotic systems in civil engineering worksites holds significant promise for improving safety, efficiency, and precision. Yet, the success of these technologies depends not only on their technical performance but also on how they are experienced and interpreted by the workforce tasked with adopting them. While existing research often emphasizes managerial or organizational perspectives, there remains a critical need to understand the viewpoints of frontline workers—those whose labor, identity, and day-to-day practices are most directly impacted by technological change.

This study re-examines a qualitative dataset originally gathered to explore professional identity, using a new analytic lens to investigate how construction workers perceive the integration of robotics through the intertwined dimensions of organizational culture, trust, and adoption readiness. By centering frontline experiences, this case study addresses persistent gaps in the literature and offers an empirically grounded framework for understanding human responses to automation in dynamic construction environments. The findings not only contribute new insights to the discourse on human-robot collaboration but also inform more inclusive and sustainable strategies for digital transformation in civil engineering.

Narrative Literature Review

The integration of robotic systems into civil engineering and construction worksites represents a transformative technological advancement with significant implications for workforce dynamics, organizational processes, and operational practices. Analysis of existing literature highlights three primary themes: workforce perceptions and acceptance, trust in human-robot interactions, and organizational culture and readiness. These themes collectively inform the successful adoption and effective integration of robotic technologies.

Workforce acceptance of robotic technologies is influenced by concerns regarding job security, employability, and job satisfaction. Employees frequently express apprehension about potential displacement due to automation, fearing redundancy and diminished job roles (Bhargava, Bester, & Bolton, 2020; Sam, Franz, Sey-Taylor, & McCarty, 2022; Emaminejad, Kath, & Akhavian, 2023). Bhargava et al. (2020) specifically emphasize the critical role that proactive organizational strategies, including transparent communication and targeted support, play in alleviating these fears and facilitating smoother technological transitions. Similarly, Sam et al. (2022) underscore the necessity of clearly managing employee expectations and providing robust support frameworks to enhance workforce receptivity and mitigate resistance.

Trust in robotic systems emerges as a crucial factor that shapes the effectiveness of human-robot collaboration (HRC). Trust is largely determined by perceptions of system reliability, transparency, safety, and consistent operational performance (Emaminejad et al., 2023; Garshasbi, Wang, Chen, & Ma, 2023). Emaminejad et al. (2023) demonstrate that technical reliability, data security, and clarity of robotic decision-making processes directly contribute to building trust among professionals in construction environments. Conversely, Sam et al. (2022) identify significant discrepancies in trust levels between managerial roles, who generally perceive robotics positively due to anticipated productivity enhancements, and frontline workers, who often maintain higher skepticism driven by operational uncertainties and practical concerns.

Organizational culture and readiness significantly influence the successful integration of robotics in civil engineering contexts. Effective adoption is closely linked to comprehensive training programs, inclusive decision-making processes, and clear communication of organizational objectives (Sreelakshmi & Mahalingam, 2023; Walzer, Graser, & Hall, 2023). Walzer et al. (2023) highlight how external economic factors, including venture capital investments, profoundly impact the strategic decisions and technological readiness of construction firms. Furthermore, Sreelakshmi and Mahalingam (2023) illustrate how digital transformations require not only technological readiness but also institutional changes in organizational culture and practices to ensure sustained adoption and effective utilization.

Despite robust scholarly attention, notable research gaps remain. Primarily, existing literature disproportionately represents managerial perspectives, leaving a critical gap in understanding frontline workers who interact directly with robotic systems. Additionally, there is a noticeable absence of longitudinal studies that track changes in workforce attitudes and perceptions over extended periods of robotic integration, limiting the insights into long-term adaptability and acceptance. Further, the majority of studies originate from Western contexts, underscoring a critical need for research across diverse cultural and geographic contexts to enhance the generalizability and comprehensiveness of findings.

Therefore, the research question guiding this study is: *how do construction workers especially those on the frontline) perceive the integration of robotics in civil engineering worksites, and what role do organizational culture, trust, and human-technology interaction play in shaping their readiness for adoption?*

Brief Research Methodology and Approach

This explanatory case study draws on data previously collected through a one-day participatory workshop with construction professionals, including site supervisors, forepersons, and frontline workers (Obi-Rapu & Simmons, 2024). Participants engaged with robotic technologies through scenario-based activities and semi-structured interviews designed to elicit detailed perspectives on the implications of robotics for day-to-day construction work. The qualitative dataset generated through these activities was originally examined with a focus on professional values and identity (Obi-Rapu & Simmons, 2024). In the present analysis, the same dataset is re-analyzed to investigate workforce perspectives

on robotic integration in civil engineering worksites through the lens of organizational culture, human-technology interaction, and adoption readiness. A thematic analysis approach was employed, guided by the research questions of this current study and supported by iterative coding and memo writing to surface new patterns and insights distinct from the earlier analysis.

Key Findings

This re-analysis revealed a layered set of workforce responses to the integration of robotics, shaped not only by practical experiences but also by broader perceptions of work, culture, and personal agency.

First, participants identified significant value in the potential of robotics to reduce physical strain and automate dangerous or repetitive tasks. These perceived benefits were often discussed in relation to workers' health, longevity in the profession, and the capacity of robotics to augment rather than replace human labor. However, this optimistic framing was conditional: participants were more supportive of robotics when they believed it would be used to enhance safety and support workers, not substitute them.

Second, concerns about job security emerged as a central theme. Many participants voiced skepticism about the long-term intentions of automation efforts, worrying that cost-saving measures might eventually lead to workforce reductions. This anxiety was particularly evident among older workers, those with lower digital fluency, and individuals whose current tasks appeared most vulnerable to automation. Importantly, the lack of clear communication from organizational leadership exacerbated these concerns, revealing a gap in strategic planning and employee engagement around technological change.

Third, the analysis highlighted the role of organizational culture in mediating acceptance of robotics. Participants described cultural environments marked by either curiosity and openness or resistance and mistrust, depending in part on how change was managed. Key levers of cultural alignment included the availability of training, the presence of peer advocates or mentors, and opportunities for workers to participate in pilot testing or feedback loops. These findings emphasize that trust in technology is often inseparable from trust in the organization deploying it.

Finally, participants reflected on how robotics might reshape the social fabric of construction sites. Some anticipated a shift toward more isolated, individualized work experiences, while others saw opportunities for job enrichment if robots could take over mundane or dangerous tasks. What unified these perspectives was an awareness that the integration of robotics is not simply a technical or operational decision, but one that affects the meaning and quality of work.

Overall, these findings underscore the necessity of centering human perspectives—particularly those of frontline workers—in the planning and implementation of robotics in civil engineering. Integration efforts must be paired with intentional communication

strategies, professional development pathways, and culturally responsive practices to ensure that innovation advances inclusively and sustainably.

Connecting Case Findings to Literature Gaps

This explanatory case study directly engages with several of the core gaps identified in the narrative literature review. Notably, it provides rich, first-person perspectives from frontline workers—an underrepresented group in the existing literature, which has primarily emphasized managerial or project leadership viewpoints (Sam et al., 2022; Sreelakshmi & Mahalingam, 2023). By surfacing worker concerns related to job displacement, communication failures, and workplace culture, this study complements and extends scholarly calls for more bottom-up, inclusionary research in technology adoption.

Moreover, while trust in robotic systems is frequently cited as a determinant of adoption (Emaminejad et al., 2023; Garshasbi et al., 2023), this case complicates that narrative by showing how trust is deeply entangled with organizational transparency and employee involvement. In practice, workers did not distinguish between trust in technology and trust in those promoting it. This insight adds nuance to current discussions of HRC by situating trust within broader systems of workplace relationships.

The study also responds to literature that calls for greater attention to cultural context and non-technical forms of adaptation (Bhargava et al., 2020; Walzer et al., 2023). Rather than framing adoption as a linear process of training or technical upskilling, participants revealed that attitudes toward robotics are embedded in relational, cultural, and intergenerational dynamics.

Future Research Directions

Building on this case to address what is critically missing in the literature, several key areas for future research emerge:

1. **Longitudinal Studies on Workforce Perception Evolution**: There is a need for research that tracks how perceptions of robotics change over time, particularly as exposure and experience with technology increase. Such studies would help clarify how initial skepticism can evolve—or persist—through various phases of implementation.
2. **Comparative Studies Across Roles and Regions**: While this study centers frontline workers, future research should examine how attitudes and adoption experiences vary across organizational levels, trades, and geographic contexts, including non-Western and rural settings where cultural norms and economic pressures may differ.
3. **Design and Evaluation of Participatory Integration Models**: Investigating models that actively engage workers in the design, testing, and refinement of robotic systems would allow researchers to assess the tangible impact of inclusion on acceptance and outcomes.

4. **Cultural and Social Dimensions of HRC**: Beyond safety and productivity, more work is needed to explore how robotics affect social dynamics on construction sites, including mentorship, identity, and belonging. These dimensions are often overlooked but are critical to workforce resilience and retention.
5. **Intervention-Based Research on Organizational Readiness**: Given the importance of organizational culture in shaping perceptions, future research should evaluate interventions aimed at improving communication, leadership trust, and training access as precursors to technology deployment.

Implications and Conclusion

This case study contributes to the growing literature on human-robot interaction by illuminating how frontline construction workers interpret, experience, and respond to the integration of robotics. By grounding the analysis in their lived experiences, the study surfaces nuanced insights into trust, culture, and identity—factors that are often underexplored in technology adoption research.

These findings affirm that successful robotic integration is not solely a matter of functionality or efficiency, but of strategic and cultural alignment. Workers' support for robotics hinges not just on their technical performance, but on how these tools are introduced, communicated, and incorporated into existing work practices and values.

Organizations in the civil engineering sector must recognize that technological transformation is also a social process. This means fostering inclusive decision-making, ensuring access to meaningful training, and preserving the human-centered values that define the construction profession. Future implementation efforts that neglect these factors risk not only operational inefficiencies but also a breakdown in worker morale and organizational trust.

As the industry continues to advance technologically, it must also evolve institutionally—investing in adaptive leadership, workforce development, and research that centers the voices of those most affected by change.

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