

Digital Transformation and the Erosion of Tacit Knowledge Transfer in Manufacturing Organizations: A Conceptual Analysis

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Abstract

Manufacturing organizations are undergoing rapid digital transformation through the adoption of enterprise resource planning systems, manufacturing execution systems, industrial internet-of-things sensors, robotic automation, and artificial-intelligence-based analytics. While these technologies improve data visibility, standardization, and process control, they also restructure the informal social conditions through which managers and shop-floor personnel have traditionally acquired tacit knowledge. This paper develops a conceptual argument that digitalization, if implemented without deliberate attention to human interaction, can weaken the informal channels of observation, apprenticeship, and face-to-face mentoring that historically sustained experiential learning in industrial settings. Drawing on Polanyi's theory of tacit knowing and Nonaka and Takeuchi's SECI model, the paper examines four digitalization trends and their implications for tacit knowledge transfer: enterprise digital systems that reduce direct supervisory contact, automation that narrows hands-on exposure to equipment behavior, remote and hybrid work arrangements that limit informal socialization, and AI-based knowledge repositories that substitute codified content for lived experience. The analysis concludes that digital transformation and tacit knowledge preservation are not inherently opposed, but organizations must consciously design "digitally embedded" social learning mechanisms rather than assuming that technology alone will preserve organizational expertise. Practical recommendations are offered for manufacturing managers seeking to balance efficiency gains with the continuity of experiential knowledge.

Keywords: digital transformation, tacit knowledge, manufacturing, organizational learning, knowledge management, Industry 4.0, automation

1. Introduction

Manufacturing enterprises across the world are investing heavily in digital infrastructure. Enterprise resource planning (ERP) platforms, manufacturing execution systems (MES), condition-monitoring sensors, robotic process automation, and predictive analytics dashboards have become standard features of contemporary industrial operations. These systems promise faster decision-making, tighter process control, and reduced dependence on individual judgment. At the same time, a substantial body of knowledge-management literature has long argued that much of what makes an organization effective resides not in its formal systems but in the tacit knowledge carried by its people: the intuitive sense an experienced operator has for when a machine is behaving abnormally, the negotiation instincts of a seasoned procurement officer, or the situational judgment of a production supervisor managing a labour dispute.

This paper asks a question that has received comparatively little direct attention in the tacit-knowledge literature: what happens to the informal social mechanisms of tacit knowledge transfer when organizations digitalize their operations? The question matters because tacit knowledge transfer has historically depended on proximity, repeated face-to-face interaction, and shared physical experience of the same equipment, materials, and disruptions. Digital transformation frequently changes the nature of that proximity. Supervisors may spend more time interpreting dashboards and less time walking the shop floor. New operators may be trained through simulation software rather than side-by-side apprenticeship. Maintenance decisions may be guided by sensor alerts rather than the accumulated "feel" of a technician. None of these shifts are inherently negative, but each of them changes the social architecture through which tacit knowledge has traditionally moved.

This paper does not argue that digitalization destroys tacit knowledge. Rather, it argues that digitalization changes the conditions under which tacit knowledge is generated and transferred, and that organizations which fail to recognize this shift risk an unintended erosion of experiential capability even as their formal data infrastructure improves. The paper is organized as follows. Section 2 reviews the theoretical foundations of tacit knowledge and situates them within the context of digital transformation. Section 3 examines four specific digitalization trends and their implications for tacit knowledge transfer. Section 4 discusses the tension between digital efficiency and experiential learning, and Section 5 offers managerial implications. Section 6 concludes.

2. Theoretical Background

2.1 Tacit Knowledge in Industrial Settings

Polanyi's foundational insight that individuals "know more than they can tell" remains central to understanding why industrial expertise is difficult to formalize. Experienced technicians, machine operators, and production managers routinely make judgments based on sensory cues, pattern recognition, and accumulated experience that resist full verbal articulation. This form of understanding develops through repeated, embodied exposure to real equipment and real disruptions rather than through documentation alone. Nonaka and Takeuchi's SECI model further clarifies that a significant share of organizational knowledge creation occurs through socialization, the direct sharing of tacit knowledge between individuals through observation and joint activity, before it is ever externalized into explicit form. Socialization, by definition, requires shared physical or interactional space.

2.2 Digital Transformation as an Organizational Restructuring Process

Digital transformation is often framed narrowly as a technology adoption process, but it is more accurately understood as a restructuring of organizational routines, communication patterns, and physical work arrangements. When an ERP system centralizes production scheduling, it changes who talks to whom, how often, and about what. When condition-monitoring sensors flag equipment anomalies automatically, they change the occasions on which a technician would otherwise have walked the floor and noticed something informally. Because tacit knowledge transfer is deeply dependent on the informal routines and physical proximity that digital systems frequently reorganize, digital transformation should be understood as having second-order effects on knowledge dynamics that are rarely considered explicitly during technology implementation.

3. Digitalization Trends and Their Implications for Tacit Knowledge Transfer

3.1 Enterprise Digital Systems and the Displacement of Supervisory Contact

ERP and MES platforms consolidate production data into centralized dashboards, allowing managers to monitor operations remotely rather than through direct floor presence. While this improves data accuracy and reduces reporting delays, it can also reduce the frequency of informal supervisory interactions during which junior staff historically absorbed contextual judgment. A production supervisor who once spent several hours daily walking the line, informally correcting technique and explaining the reasoning behind decisions, may increasingly spend that time reviewing dashboard exceptions instead. The explicit data captured by the system improves, but the implicit coaching that used to accompany floor presence diminishes unless deliberately preserved.

3.2 Automation and the Narrowing of Hands-On Exposure

Robotic automation and automated quality-inspection systems reduce the frequency with which operators must directly diagnose equipment behavior. This has clear efficiency and safety benefits, particularly for repetitive or hazardous tasks. However, tacit diagnostic skill, such as recognizing early signs of machine wear through sound, vibration, or visual cues, develops through repeated hands-on troubleshooting. As automated systems increasingly perform first-line diagnostics, newer employees may have fewer opportunities to develop this embodied sensitivity, creating a long-term dependency on the automated system's own diagnostic accuracy and a potential capability gap if the system fails or encounters novel conditions it was not designed to detect.

3.3 Remote and Hybrid Work Arrangements

Digital collaboration tools have enabled greater flexibility in managerial and engineering roles, including remote monitoring of multiple plants from a central location. While this expands managerial reach, it also reduces the incidental, unplanned interactions, corridor conversations, shared lunch breaks, informal shop-floor visits, through which much tacit knowledge has historically diffused. Scheduled virtual meetings tend to be structured around explicit agenda items, leaving little room for the unplanned storytelling and situational anecdotes that traditionally carried contextual lessons between colleagues.

3.4 AI-Based Knowledge Repositories and the Illusion of Captured Expertise

Organizations increasingly deploy AI-based knowledge management systems, chatbots, searchable repositories, and natural-language query tools, with the expectation that these systems can capture and redistribute expert knowledge. While such systems are valuable for storing explicit procedures and frequently asked questions, they risk creating an illusion that tacit expertise has been successfully codified when, in fact, only the explicit surface of that expertise has been captured. A maintenance chatbot may retrieve a documented troubleshooting procedure, but it cannot replicate the situational judgment an experienced technician uses to decide when standard procedure should be deviated from. Overreliance on such systems may discourage organizations from investing in the slower, relationship-based mechanisms through which deeper tacit understanding is actually formed.

3.5 Sectoral Variation: Large Manufacturers versus Small and Medium Enterprises

The implications of digitalization for tacit knowledge transfer are unlikely to be uniform across all manufacturing contexts. Large manufacturers typically possess dedicated learning-and-development functions, formal training budgets, and sufficient scale to design structured knowledge-transfer programs alongside digital transformation initiatives. Small and medium-sized manufacturing enterprises (SMEs), by contrast, often rely almost entirely on informal, person-to-person channels for tacit knowledge transfer, precisely because they lack the resources to formalize training. For such organizations, the informal supervisory contact and shop-floor presence discussed in Section 3.1 may represent the primary, and sometimes only, mechanism through which junior staff acquire operational judgment. Consequently, SMEs may be disproportionately vulnerable to the unintended erosion of tacit knowledge transfer when they adopt digital systems designed primarily with large-enterprise efficiency assumptions in mind, without the compensating structured training investment that larger organizations can more readily afford.

4. Discussion: Balancing Digital Efficiency and Experiential Learning

The preceding analysis suggests that digital transformation and tacit knowledge preservation are not automatically compatible outcomes of the same technology investment. Organizations that treat digitalization purely as an efficiency initiative risk inadvertently narrowing the informal channels through which experiential judgment has traditionally been cultivated. At the same time, digital tools are not inherently destructive to tacit knowledge; they can, if deliberately designed, create new occasions for socialization. Video-based training platforms can preserve and share demonstrations of expert technique. Digital collaboration spaces can be intentionally structured to include informal discussion forums rather than only task-oriented channels. Sensor data can be paired with expert commentary rather than presented as a replacement for human judgment.

The central implication is that the erosion of tacit knowledge transfer under digitalization is not inevitable but is a design choice, often an unintentional one, made when organizations optimize digital systems purely for data efficiency without considering their social and pedagogical side effects. Manufacturing organizations that wish to modernize without hollowing out their experiential capability need to treat knowledge continuity as an explicit design criterion for digital transformation initiatives, alongside cost, speed, and accuracy.

5. Managerial Implications

Several practical implications follow from this analysis. First, organizations implementing ERP, MES, or automation systems should conduct a "tacit knowledge impact assessment" alongside standard technology rollout planning, identifying which informal interactions the new system may displace and designing compensating mechanisms. Second,

digital dashboards should be paired with structured floor-presence expectations for supervisors, ensuring that data visibility supplements rather than substitutes for direct observation. Third, automation of diagnostic tasks should be phased in a manner that still exposes newer employees to sufficient hands-on troubleshooting during their formative years, potentially through simulation-based training that recreates diagnostic challenges the automated system now handles routinely. Fourth, AI-based knowledge repositories should be explicitly framed to users as tools for accessing explicit procedures rather than substitutes for mentorship, and organizations should continue to invest separately in mentoring and communities of practice even as they adopt such systems.

6. Limitations of the Conceptual Approach

As a conceptual and integrative analysis, this paper does not present empirical measurement of the relationship between digitalization and tacit knowledge outcomes, and its arguments should be read as a set of propositions for further empirical investigation rather than established findings. The four digitalization trends discussed in Section 3 are not exhaustive, and their relative significance is likely to vary by industry sub-sector, organizational size, and national labour-market context. Furthermore, the paper's emphasis on potential risks of digitalization should not be read as an argument against digital adoption; rather, it is intended to draw attention to a dimension of digital transformation planning, knowledge continuity, that is frequently absent from technology implementation frameworks focused primarily on return on investment and process efficiency. Future empirical work, including longitudinal case studies of manufacturing plants before and after major digital transformation initiatives, would help to establish whether the mechanisms proposed here operate as described and whether the compensating design strategies discussed in Section 5 are effective in practice.

7. Conclusion

This paper has argued that digital transformation in manufacturing organizations carries significant, often unexamined, implications for the informal social mechanisms through which tacit knowledge has traditionally been generated and transferred. Enterprise digital systems, automation, remote work arrangements, and AI-based knowledge repositories each alter the conditions of proximity, observation, and interaction on which tacit knowledge transfer depends. Rather than treating digitalization and experiential knowledge preservation as competing priorities, organizations should consciously design digital transformation initiatives that account for their social and pedagogical consequences. Future empirical research could examine how specific digital interventions affect measurable knowledge-transfer outcomes across different manufacturing contexts, and how hybrid models combining digital efficiency with deliberate human interaction perform relative to purely digital or purely traditional approaches.

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