Employee Engagement as a Digital Twin Innovation Driver: Conceptual Framework

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Abstract: Organisations across sectors face intensifying pressure to innovate as digital transformation reshapes operations, structures and decision-making. Digital twin technologies have become critical strategic tools, enabling simulation, real-time monitoring and process optimisation. Yet most implementations remain techno-centric, prioritising system architectures over the human dimensions essential for transformative impact. This study develops an integrated conceptual framework placing employee engagement and knowledge processes at the core of digital twin-enabled innovation, bridging three previously disconnected research streams. Using a integrative review of peer reviewed literature on employee engagement and innovation, digital transformation/ change management and digital twin adoption (2020–2026), comparative thematic analysis mapped conceptual convergences and revealed key theoretical gaps, particularly how human factors translate digital twin capabilities into organisational innovation. The resulting framework posits employee engagement as the primary mediating mechanism through which digital twin-driven change produces multilevel innovation outcomes. Knowledge sharing acts as a secondary mediator, converting individual experimentation into collective organisational learning, while leadership support, learning culture and change readiness serve as contextual moderators. Digital twin initiatives demand real-time data interpretation and cross-functional collaboration, challenges engaged employees meet through vigour, dedication and proactive problem-solving. The model defines a sequential pathway in which digital twin-enabled change enhances engagement, which stimulates knowledge sharing and generates individual innovative behaviours, team problem-solving and organisational process and service innovation, sustained by dynamic feedback loops from successful outcomes. This framework makes three original contributions: (1) integration of organisational behaviour, innovation management and information systems through mechanisms linking engagement, knowledge sharing and innovation; (2) new micro-foundational insights connecting human behavioural dynamics with Industry 5.0 digital twin technologies; and (3) actionable guidance for managers to design digital twin programmes as integrated socio-technical change initiatives fostering engagement and institutionalised knowledge sharing. The study outlines priorities for multilevel, longitudinal and cross-sector empirical research to test these propositions and advance human-centric digital twin innovation.

Keywords: Employee engagement, Digital twin, Innovation, Knowledge sharing, Change management, Industry 5.0

1. Introduction

Organisations across sectors face competitive, technological and societal pressures to innovate continuously using rich digital data (Bieńkowska et al., 2025; Chrusciaka et al., 2025). Digital transformation is a strategic imperative that represents significant organisational change, reshaping structures, processes, roles and cultures beyond mere technological upgrades (Marzi et al., 2023; Bieńkowska et al., 2025). Digital twins are virtual replicas of physical assets, processes or systems, synchronised with real world data, which enable data-driven simulation, monitoring and optimisation, supporting predictive maintenance, scenario simulation, process optimisation, service innovation and organisational-level strategy testing (Emmert-Streib, 2023; Krupas et al., 2024; Lyytinen et al., 2024; Rahmani et al., 2024; Yao et al., 2023).

As digital twin initiatives grow, Industry 5.0 and human-centric transformation focus on socio-technical systems. These highlight human-machine collaboration, sustainability, resilience and worker well-being (Martini, Bellisario and Coletti, 2024; Khule et al., 2026). Digital twins reshape routines, skills and collaboration as employees use dashboards, models and real-time data. Thus, a socio-organisational lens is essential (Krupas et al., 2024; Rahmani, Jesus and Lopes, 2024). Viewing digital twins only as technical artefacts overlooks the behavioural conditions needed for innovation (Bieńkowska et al., 2025; Chrusciaka et al., 2025; Krupas et al., 2024; Martini et al., 2024).

Employee engagement is a positive state of energy and dedication. It drives innovative work behaviour, idea generation and service innovation by building creative self-belief and encouraging problem-solving. Digital twins require employees to adapt to data-driven routines, work across functions and keep learning. Engagement plays a key role in the adoption and using digital twins for innovation.

Yet the literature remains fragmented. Engagement-innovation studies focus on generic settings, with little attention to digital twins (Ali, Li and Qiu, 2022; Ghani et al., 2023; Elamin et al., 2024; Wang et al., 2024). Digital twin research prioritises technical aspects, sidelining human factors (Marzi et al., 2023; Yao et al., 2023; Rahmani, Jesus and Lopes, 2024). Change management rarely integrates engagement and knowledge sharing as mechanisms translating technology into innovation (Chrusciaka et al., 2025; Marzi et al., 2023).

Empirical evidence links engagement to innovation, creativity, knowledge sharing and open service innovation (Ali, Li and Qiu, 2022; Ghani et al., 2023; Elamin et al., 2024; Wang et al., 2024). Digital transformation studies stress leadership, culture, readiness and communication for human-centric success (Kehrbusch and Engels, 2023; Marzi et al., 2023; Bieńkowska et al., 2025; Chrusciaka et al., 2025). Digital twin research highlights technical integration and operations, with a still under-integrated human-machine focus (Yao et al., 2023; Krupas et al., 2024; Martini, Bellisario and Coletti, 2024; Rahmani, Jesus and Lopes, 2024; Bieńkowska et al., 2025). No framework theorises engagement via knowledge sharing, links digital twin change to innovation and moderates it through leadership, culture and readiness.

This paper asks: How do employee engagement and knowledge sharing drive innovation during digital twin-enabled change? The authors aim to: (1) Review the literature on engagement, innovation, digital transformation and digital twins to find research gaps; (2) Develop a framework showing engagement and knowledge sharing as key links between change and innovation; (3) Suggest future research on multiple levels, over time and across sectors.

This work introduces a framework that shifts from a techno-centric to a human-centric perspective. It centres engagement and knowledge in digital twin innovation through mediating and moderating mechanisms (Krupas et al., 2024; Martini, Bellisario and Coletti, 2024; Bieńkowska et al., 2025; Chrusciaka et al., 2025). It also provides micro-foundations for scholars (Ali, Li and Qiu, 2022; Elamin et al., 2024; Krupas et al., 2024)and actionable guidance for managers on human-centric governance (Kehrbusch and Engels, 2023; Bieńkowska et al., 2025).

2. Literature Review

2.1 Employee Engagement and Innovation

Employee engagement is a positive work-related state of vigour, dedication and absorption. It reflects the psychological presence and energy invested in work roles (Schaufeli, 2017; Ali, Li and Qiu, 2022). This state includes cognitive focus on tasks, emotional commitment to goals and proactive behaviour beyond formal requirements (Ghani et al., 2023; Elamin et al., 2024; Wang et al., 2024). Engagement thus mobilises cognitive, emotional and behavioural energy for problem-solving, collaboration and innovation at work.

Research links employee engagement to innovative work behaviour, creativity and innovation outcomes. Engaged employees are more likely to generate, promote and implement novel ideas, even when obstacles arise (Zhang and Bartol, 2010; Ali, Li and Qiu, 2022; Ghani et al., 2023; Wang et al., 2024). In services, engagement drives open innovation through creative self-efficacy and innovative work behaviour-mediated processes (Wan et al., 2022). Other mechanisms (learning orientation, thriving at work and psychological safety) enable experimentation, risk-taking and new approaches to work (Ghani et al., 2023; Elamin et al., 2024; Gao, Chen and Jiang, 2025).

Knowledge processes are central to this nexus. Engagement positively associates with knowledge-sharing behaviours, including the exchange of expertise, ideas and experiential insights (Bailey et al., 2017; Ali, Li and Qiu, 2022; Wang et al., 2024). Energetic, committed employees share explicit and tacit knowledge, facilitating individual creativity, team-level innovation and organisational learning (Wan et al., 2022; Wang et al., 2024). Visionary/empowering leadership effects on innovative work behaviour operate through knowledge sharing and creativity, positioning engagement and knowledge processes as joint innovation pathways (Alobeidli, Ahmad and Jabeen, 2024).

2.2 The Missing Crossover

The reviewed literature reveals a significant underexplored intersection. Digital twin projects reshape work routines through data-intensive tasks, dashboard use and simulation-based decision-making; alter competencies such as data literacy, systems thinking and cross-functional coordination; and reconfigure collaboration as employees interpret/act on shared digital model (Krupas et al., 2024; Rahmani, Jesus and Lopes, 2024). Success depends not only on technical robustness but also on employees' willingness to learn, experiment and integrate digital twin insights into practice.

Digital twin-enabled innovation proves fundamentally human-dependent. Technological potential requires activation through employee engagement, collaborative behaviours and knowledge processes (Martini, Bellisario and Coletti, 2024; Bieńkowska et al., 2025; Chrusciaka et al., 2025). Engagement channels adoption into proactive participation, idea generation and problem-solving persistence amid simulation complexity/ uncertainty (Ali, Li and Qiu, 2022; Wang et al., 2024).

Knowledge sharing mediates as a key process: engaged employees share explicit knowledge (dashboard use, indicator interpretation) and tacit knowledge (process nuances, workarounds), transforming individual experimentation into collective learning, cross-functional problem-solving and new digital twin-enabled services/ business models (Bailey et al., 2017; Wan et al., 2022; Wang et al., 2024).

This pathway's strength depends on contextual moderators: innovation-supportive/ learning-oriented leadership encourages engagement and legitimises experimentation with resource allocation (Elamin et al., 2024; Gao, Chen and Jiang, 2025; Okanlawon et al., 2025); learning culture/ psychological safety enables new digital twin uses, model/ data error surfacing and open failure discussion (Martini, Bellisario and Coletti, 2024; Bieńkowska et al., 2025);change readiness/ digital mindset determines constructive involvement versus anxiety/withdrawal (Marzi et al., 2023).

No existing framework explicitly integrates employee engagement (core mechanism), knowledge sharing (mediator) and contextual moderators (leadership/ culture/ readiness) to explain digital twin-enabled innovation outcomes. Current research examines engagement/ innovative work behaviour generically, digital transformation without specificity to digital twins, or digital twins through technical lenses that lack human mechanisms.

3. Methodology

3.1 Methodological Approach and Review Design

The authors adopted a conceptual paper design grounded in an integrative literature review to develop a human-centric framework linking employee engagement, knowledge sharing and innovation in digital twin-enabled organisational change (Torraco, 2005, 2016; Snyder, 2019). This approach proved appropriate given the heterogeneous, multi-disciplinary nature of the relevant literatures, employee engagement/ innovative work behaviour, change management in digital transformation and digital twin research, at varying maturity levels, where narrow effect-size aggregation was neither feasible nor desirable (Snyder, 2019). Rather than testing predefined hypotheses, this approach used existing work to build new conceptual linkages and a provisional theoretical model, consistent with integrative reviews in emerging domains (Torraco, 2016).

The review pursued three interrelated goals aligned with the article's structure. First, the authors consolidated core constructs across fields, clarifying definitions and operationalisations of employee engagement, innovative work behaviour, knowledge sharing, digital transformation and digital twin-enabled change (Ali, Li and Qiu, 2022; Marzi et al., 2023; Krupas et al., 2024; Rahmani, Jesus and Lopes, 2024). Second, the authors identified and aligned conceptual relationships across the engagement-innovation, digital transformation/ change and digital twin literatures, emphasising mediating knowledge processes and contextual factors such as leadership, culture and readiness (Martini, Bellisario and Coletti, 2024; Chrusciaka et al., 2025). Third, the authors used this synthesis to identify gaps and articulate a future research agenda to guide multilevel, longitudinal and cross-sector empirical work on digital twin-enabled innovation (Snyder, 2019). The article's structure around these aims maintained clear alignment between the research problem, the review process and the proposed framework, per best-practice integrative review guidance (Torraco, 2005, 2016).

3.2 Search Strategy

The authors searched Scopus and Web of Science for peer-reviewed journal articles, complemented by select high-quality reports and standards for definitional clarity on digital twins and digital transformation (Emmert-Streib, 2023; Yao et al., 2023; Rahmani, Jesus and Lopes, 2024). The timeframe (approx. 2020-2026) captured the maturation of engagement-innovation research alongside accelerating digital transformation/ digital twin developments (Ali, Li and Qiu, 2022; Marzi et al., 2023; Krupas et al., 2024).

Search terms combined (a) engagement/ innovation keywords such as, "employee engagement," "work engagement," "innovative work behaviour," "employee creativity," "knowledge sharing", with (b) digital transformation/ digital twin terms: "digital transformation", "organisational change", "change management", "digital twin", "digital twin of an organization", "human-centric digital transformation" (Marzi et al., 2023;

Barata and Kayser, 2024; Rahmani, Jesus and Lopes, 2024). Backwards/ forward citation tracking on key reviews identified additional studies (Torraco, 2016; Snyder, 2019).

Inclusion criteria required: (1) peer-reviewed status; (2) placement in management, organisational behaviour/ human resource management, innovation, information systems, operations, or related fields; (3) addressing focal constructs, employee engagement, innovative work behaviour/creativity, knowledge sharing, digital transformation/ change, digital twin technologies, with explicit organisational/ human implications (Ali, Li and Qiu, 2022; Marzi et al., 2023). Both conceptual and empirical studies were included, as integrative reviews benefit from combined theoretical/ empirical insights for framework development. Exclusions comprised highly technical digital twin papers focused solely on architectures/ algorithms/ engineering without organisational/ human dimensions, plus non-peer-reviewed opinion pieces (except practitioner reports contextualising digital twin definitions/ applications) (Yao et al., 2023; Rahmani, Jesus and Lopes, 2024). After removing duplicates and clearly irrelevant records, 23 studies met the inclusion criteria for in-depth analysis. Among these, 9 focused on theories of employee engagement and innovative work behaviour. Four studies examined digital transformation and human-centric change management. The remaining 10 studies addressed digital twins and Industry 5.0, including topics like human–machine collaboration and human digital twins (Ali, Li and Qiu, 2022; Marzi et al., 2023; Krupas et al., 2024; Martini, Bellisario and Coletti, 2024; Rahmani, Jesus and Lopes, 2024; Wang et al., 2024; Bieńkowska et al., 2025; Chrusciaka et al., 2025; Okanlawon et al., 2025). All of these studies appeared in peer-reviewed journals indexed in Scopus or Web of Science. They span management, organisational behaviour, human resource management, innovation, information systems, and operations.

The analysis used a structured, iterative process, following integrative review guidelines (Torraco, 2005, 2016; Snyder, 2019). First, titles and abstracts were screened to exclude irrelevant records. Then, full texts were read to ensure each study's concepts and scope matched the research aims. During in-depth analysis, authors documented definitions, theoretical lenses, key variables, and main findings using an extraction template. This approach enabled systematic comparisons across studies and literature streams (Ali, Li and Qiu, 2022; Marzi et al., 2023; Krupas et al., 2024).

To go beyond a descriptive review, studies were mapped along four dimensions: main focus (engagement and innovation; digital transformation and change management; digital twins), level of analysis (individual, team, or organisational), knowledge processes (knowledge sharing, learning, and related topics), and contextual factors (such as leadership, culture, change readiness, and human-centric design or human factors) (Martini, Bellisario and Coletti, 2024; Wang et al., 2024; Chrusciaka et al., 2025) mapping revealed patterns. Most studies on engagement and innovative work behaviour operated at the individual level, treating leadership or culture as contextual enablers (Zhang and Bartol, 2010; Bailey et al., 2017; Ghani et al., 2023; Elamin et al., 2024). Some engagement and digital transformation studies specifically discussed knowledge sharing and learning as mediators (Ali, Li and Qiu, 2022; Wan et al., 2022; Gao, Chen and Jiang, 2025). In comparison, digital twin and Industry 5.0 studies, despite deep technical and system-level insights, usually did not include individual-level engagement or knowledge processes. They typically defined context in terms of readiness, governance, and ergonomics (Emmert-Streib, 2023; Yao et al., 2023; Krupas et al., 2024; Rahmani, Jesus and Lopes, 2024; Bieńkowska et al., 2025).

Building on this mapping, the review compared antecedents, mediators, and outcomes across three research areas, identifying common themes, tensions, and gaps (Snyder, 2019). The review contrasted organisational behaviour and human resource management models, where engagement and knowledge sharing mediate leadership's influence on innovative work behaviour (Ali, Li and Qiu, 2022; Ghani et al., 2023; Elamin et al., 2024), with digital transformation studies that treat leadership, culture, and readiness as enablers of adoption and change (Kehrbusch and Engels, 2023; Bieńkowska et al., 2025; Chrusciaka et al., 2025). It also compared these to digital twin studies, which focus mostly on technical context (Marzi et al., 2023; Rahmani, Jesus and Lopes, 2024). Through iterative reading, coding, and diagramming, these patterns were synthesised into the integrative framework and propositions described in the next section. The framework explains how employee engagement, knowledge sharing, and contextual moderators interact to shape digital twin-enabled innovation and suggests future research directions, including empirical designs, levels of analysis, and sectoral contexts for testing and extending the model (Snyder, 2019).

4. Results and Discussion

4.1 Integrative Analysis and Conceptual Framework

Digital twin-enabled organisational change is not merely a technological upgrade but a socio technical transition that reshapes how employees interpret information, coordinate action and contribute to innovation. As organisations embed digital twins into processes and systems, employees engage with real time data and simulation environments, and translate virtual insights into decisions (Yao et al., 2023; Krupas et al., 2024; Rahmani, Jesus and Lopes, 2024) Given the informational intensity, interdependence and uncertainty of these environments, technological capability alone is insufficient; sustained innovation depends on employees adopting new routines, experimenting with unfamiliar problem solving and collaborating across boundaries (Martini, Bellisario and Coletti, 2024; Bieńkowska et al., 2025; Chrusciaka et al., 2025).

Employee engagement is therefore central. Engaged employees display vigour, dedication, absorption, initiative and persistence, which support innovative work behaviour and creativity (Ali, Li and Qiu, 2022; Ghani et al., 2023; Wang et al., 2024). In digital twin contexts, these qualities enable employees to interpret dashboards, question simulations, identify anomalies and translate digital signals into improvements. Engagement thus functions as a behavioural mechanism that links digital twin-enabled change to innovation, particularly in ambiguous and complex contexts.

Engagement is reinforced by knowledge sharing. Research shows that engaged employees are more likely to exchange ideas and experiential know how, transforming individual contributions into collective learning (Bailey et al., 2017; Ali, Li and Qiu, 2022; Wan et al., 2022; Elamin et al., 2024; Gao, Chen and Jiang, 2025). In digital twin environments, knowledge sharing enables employees to interpret and embed the technology into workflows, turning isolated experimentation into team-driven problem solving and broader innovation.

These mechanisms are shaped by organisational context. Leadership, culture, communication and readiness influence whether digital change is perceived as an opportunity or threat (Kehrbusch and Engels, 2023; Marzi et al., 2023; Bieńkowska et al., 2025; Chrusciaka et al., 2025). Human centric Industry 5.0 and digital twin research further emphasise well being, collaborative design and organisational support as conditions for (Krupas et al., 2024; Martini, Bellisario and Coletti, 2024; Okanlawon et al., 2025). However, these factors are rarely explicitly connected to engagement and knowledge sharing mechanisms, despite shaping whether engagement is activated, knowledge circulates, and innovation emerges.

The framework developed in this study positions digital twin-enabled organisational change as the triggering condition, employee engagement as the primary behavioural mechanism, knowledge sharing as a mediating process and leadership, culture and readiness as contextual moderators. It integrates three literature streams, engagement and innovative work behaviour, digital transformation and change management, and digital twin and Industry 5.0, explaining how digital twin initiatives can move beyond technical optimisation to enable innovation through human participation and shared learning. Figure 1 summarises this framework.

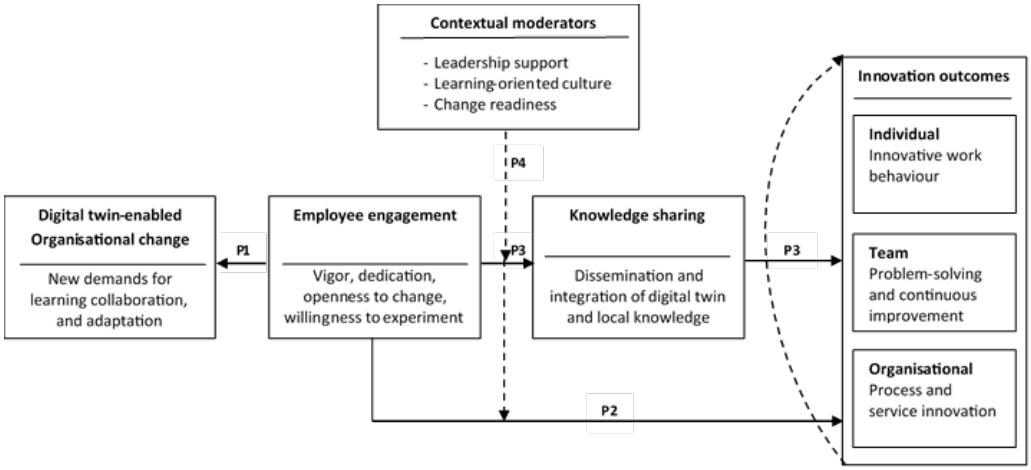


Figure 1: Conceptual framework of employee engagement, knowledge sharing and innovation in digital twin-enabled organisational change

4.2 Theoretical Implications

The framework offers three theoretical contributions. First, it integrates fragmented literatures by connecting organisational behaviour/ human resource management engagement/ innovative work behaviour research with innovation management/digital transformation/ digital twin studies (Marzi et al., 2023; Krupas et al., 2024; Rahmani, Jesus and Lopes, 2024). This embeds engagement-innovation models within data-intensive, simulation-based digital twin-enabled change. Second, it humanises digital twin research by integrating microfoundational mechanisms, namely engagement and knowledge sharing, amid technical/operational dominance (Krupas et al., 2024; Rahmani, Jesus and Lopes, 2024). Third, it refines engagement theory, positioning it as pivotal in high-uncertainty/technology-mediated change, with specified knowledge processes and contextual contingencies (leadership/ culture/ readiness) (Martini, Bellisario and Coletti, 2024; Bieńkowska et al., 2025; Chrusciaka et al., 2025).

4.3 Practical Implications

Digital twin initiatives should be managed as organisation wide change programmes, not just narrow IT projects. Innovative value depends on employees' understanding of the purpose, their engagement with new routines, and their perception of change as meaningful. Managers should design implementations to foster engagement, rather than assume it will emerge spontaneously. Leadership support must be visible and participative, with clear communication on why the digital twin is introduced, the expected benefits, and the desired experimentation. Avoid using surveillance oriented framing, as it can trigger resistance (Kehrbusch and Engels, 2023; Marzi et al., 2023; Bieńkowska et al., 2025; Chrusciaka et al., 2025). Organisations should also cultivate learning cultures and readiness through knowledge sharing routines and targeted data literacy training. Experimentation with dashboards, simulations and anomaly detection in digital twin environments should be supported by HRM practices that reinforce proactive problem solving and knowledge exchange (Ghani et al., 2023; Barata and Kayser, 2024; Krupas et al., 2024; Wang et al., 2024).

5. Conclusion

This study examined how employee engagement and knowledge sharing drive innovation during digital twin-enabled organisational change, based on an integrative review of recent work on engagement and innovative work behaviour, digital transformation and digital twins. The analysis shows that digital twin initiatives create data intensive, uncertain work contexts in which technological sophistication alone is insufficient; innovation depends on employees' willingness to engage, experiment and share knowledge across functions. In direct answer to the research question, the proposed framework explains how digital twin-enabled change enhances engagement, how engagement stimulates knowledge sharing and how these mechanisms, conditioned by leadership support, learning culture and change readiness, generate innovation at individual, team and organisational levels. The study advances a human centric understanding of digital twins and outlines an agenda for future empirical research, encouraging scholars and practitioners to treat engagement and knowledge processes as core design variables in digital twin programmes.

Like all conceptual, review-based work, this study has limitations that warrant acknowledgement. First, the proposed framework remains theoretically grounded but empirically untested and therefore requires validation. Second, reliance on predominantly English-language, indexed sources may have introduced selection bias, underrepresenting insights from non-indexed or non-English work. Third, digital twin technologies evolve rapidly and vary across sectors, so the relationships advanced here may depend on specific architectures, regulatory environments and organisational contexts, limiting generalisability over time and across settings.

Future research should prioritise empirical tests of the framework in diverse digital twin-enabled contexts, using quantitative studies in manufacturing, services and public administration to examine how engagement, knowledge sharing and contextual moderators jointly shape innovation outcomes. Multilevel and longitudinal designs are particularly valuable to link individual engagement and knowledge sharing to team learning and organisational innovation across implementation phases. Qualitative case studies, mixed methods designs, and action research can deepen understanding of how leadership, culture and readiness are enacted in practice and how engagement and knowledge processes are designed, experienced and adjusted in digital twin programmes.

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References

Ali, H., Li, M., & Qiu, X. (2022). Employee engagement and innovative work behavior among Chinese millennials: Mediating and moderating role of work-life balance and psychological empowerment. Frontiers in Psychology, 13. https://doi.org/10.3389/fpsyg.2022.942580

Alobeidli, S. Y., Ahmad, S. Z., & Jabeen, F. (2024). Mediating effects of knowledge sharing and employee creativity on the relationship between visionary leadership and innovative work behavior. Management Research Review, 47(6), 883–903. https://doi.org/10.1108/MRR-02-2023-0144

Bailey, C., Madden, A., Alfes, K., & Fletcher, L. (2017). The meaning, antecedents and outcomes of employee engagement: A narrative synthesis. International Journal of Management Reviews, 19(1), 31–53. https://doi.org/10.1111/ijmr.12077

Barata, J., & Kayser, I. (2024). How will the digital twin shape the future of Industry 5.0? Technovation, 134. https://doi.org/10.1016/j.technovation.2024.103025

Bieńkowska, A., Tworek, K., Voropai, O., & Zimmer, J. (2025). Human-centric approach to creating sustainable innovation in the context of Industry 5.0. Entrepreneurial Business and Economics Review, 13(3), 115–134. https://doi.org/10.15678/EBER.2025.130306

Chrusciaka, C. B., Szejkaa, A. L., Juniora, O. C., & Schaefera, J. L. (2025). Human-centric process improvement through digital transformation: Contributions and limitations. Production, 35. https://doi.org/10.1590/0103-6513.20240109

Elamin, A. M., Aldabbas, H., Ahmed, A. Z. E., & Abdullah, A. N. (2024). Employee engagement and innovative work behavior: The mediating role of knowledge-sharing behavior in the United Arab Emirates (UAE) service context. Administrative Sciences, 14(9). https://doi.org/10.3390/admsci14090232

Emmert-Streib, F. (2023). Defining a digital twin: A data science-based unification. Machine Learning and Knowledge Extraction, 5(3), 1036–1054. https://doi.org/10.3390/make5030054

Gao, S., Chen, J., & Jiang, P. (2025). How does digital knowledge management drive employees' innovative behavior? Sustainability, 17(17). https://doi.org/10.3390/su17177823

Ghani, B., Hyder, S. I., Yoo, S., & Han, H. (2023). Does employee engagement promote innovation? The facilitators of innovative workplace behavior via mediation and moderation. Heliyon, 9(11). https://doi.org/10.1016/j.heliyon.2023.e21817

Kehrbusch, B., & Engels, G. (2023). Digital transformation—Towards flexible human-centric enterprises. In Digital Transformation (pp. 497–526). Springer. https://doi.org/10.1007/978-3-662-65004-2_20

Khule, S., Sihare, M., Arora, R., Dixit, N., Dubey, G., & Sharma, Y. K. (2026). Human-machine collaboration in industry 5.0 using big data analytics. In Transforming Industries, Empowering Societies (pp. 15–26). https://doi.org/10.1016/B978-0-443-32878-7.00019-5

Krupas, M., Kajati, E., Liu, C., & Zolotova, I. (2024). Towards a human-centric digital twin for human–machine collaboration: A review on enabling technologies and methods. Sensors, 24(7). https://doi.org/10.3390/s24072232

Lyytinen, K., Weber, B., Becker, M. C., & Pentland, B. T. (2024). Digital twins of organization: Implications for organization design. Journal of Organization Design, 13(3), 77–93. https://doi.org/10.1007/s41469-023-00151-z

Martini, B., Bellisario, D., & Coletti, P. (2024). Human-centered and sustainable artificial intelligence in Industry 5.0: Challenges and perspectives. Sustainability, 16(13). https://doi.org/10.3390/su16135448

Marzi, G., Fakhar Manesh, M., Caputo, A., Pellegrini, M. M., & Vlačić, B. (2023). Do or do not. Cognitive configurations affecting open innovation adoption in SMEs. Technovation, 119. https://doi.org/10.1016/j.technovation.2022.102585

Okanlawon, T. T., Oyewobi, L. O., Kabir, I., Badamasi, A., Dodo, M., & Jimoh, R. A. (2025). Enhancing the integration of digital twin in construction phases: Key drivers for adoption in Nigeria. Journal of Engineering, Design and Technology. Advance online publication. https://doi.org/10.1108/JEDT-03-2025-0120

Rahmani, R., Jesus, C., & Lopes, S. I. (2024). Implementations of digital transformation and digital twins: Exploring the factory of the future. Processes, 12(4). https://doi.org/10.3390/pr12040787

Schaufeli, W. B. (2017). Applying the Job Demands-Resources model: A "how to" guide to measuring and tackling work engagement and burnout. Organizational Dynamics, 46(2), 120–132. https://doi.org/10.1016/j.orgdyn.2017.04.008

Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. Journal of Business Research, 104, 333–339. https://doi.org/10.1016/j.jbusres.2019.07.039

Torraco, R. J. (2005). Writing integrative literature reviews: Guidelines and examples. Human Resource Development Review, 4(3), 356–367. https://doi.org/10.1177/1534484305278283

Torraco, R. J. (2016). Writing integrative literature reviews: Using the past and present to explore the future. Human Resource Development Review, 15(4), 404–428. https://doi.org/10.1177/1534484316671606

Wan, X., He, R., Zhang, G., & Zhou, J. (2022). Employee engagement and open service innovation: The roles of creative self-efficacy and employee innovative behaviour. Frontiers in Psychology, 13. https://doi.org/10.3389/fpsyg.2022.921687

Wang, B., Zhou, H., Li, X., Yang, G., Zheng, P., Song, C., Yuan, Y., Wuest, T., Yang, H., & Wang, L. (2024). Human digital twin in the context of Industry 5.0. Robotics and Computer-Integrated Manufacturing, 85. https://doi.org/10.1016/j.rcim.2023.102626

Yao, J. F., Yang, Y., Wang, X. C., & Zhang, X. P. (2023). Systematic review of digital twin technology and applications. Visual Computing for Industry, Biomedicine, and Art, 6(1). https://doi.org/10.1186/s42492-023-00137-4

Zhang, X., & Bartol, K. M. (2010). Linking empowering leadership and employee creativity: The influence of psychological empowerment, intrinsic motivation, and creative process engagement. Academy of Management Journal, 53(1), 107–128. https://doi.org/10.5465/amj.2010.48037118