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Integrating AI into Kaizen Events for Continuous Improvement in the 21st Century

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Abstract: ***This article explores the evolving integration of Artificial Intelligence (AI) into Kaizen practices within Lean manufacturing systems. It examines how AI-enhanced Kaizen events contribute to operational efficiency, adaptive learning, and human-centric innovation across industry sectors. Drawing on frameworks such as Neutrosophic Cognitive Mapping and Digital Kaizen, the study proposes a conceptual model that aligns continuous improvement with Industry 4.0 and 5.0 principles. It emphasizes the role of psychological enablers, leadership styles, and emotional dynamics in sustaining effective implementation. The article concludes that AI augments, rather than replaces, the human elements of Kaizen, offering a forward-looking perspective on sustainable, digital-first improvement strategies.***

Keywords: Industry 5.0, Kaizen, Digital Kaizen, Neutrosophic Cognitive Mapping, human–cyber–physical systems (hcps)

1. Introduction

Lean manufacturing has evolved into a multifaceted system of practices-such as 5S, Total Productive Maintenance (TPM), Just-in-Time (JIT), and Kaizen-that together form a cohesive philosophy rather than a single, rigid framework (Bhamu & Sangwan, 2014). Among these, Kaizen-meaning "change for the better"-stands out as a foundational principle of continuous improvement. Traditionally, Kaizen events are structured, collaborative workshops aimed at streamlining specific processes. These sessions bring together employees at all levels, from executives to frontline workers, to identify inefficiencies (commonly referred to as waste) and implement incremental, targeted changes. Kaizen now stands as a cornerstone of Lean manufacturing and adaptive design frameworks. Its emphasis on incremental improvement, team empowerment, and process visibility has made it a cornerstone of operational excellence across industries. (Kareska, 2024).

While Kaizen is often discussed as a broad philosophy of continuous improvement, this paper focuses specifically on Kaizen events-short-term, structured workshops aimed at rapid process enhancement. These events typically span several days and involve cross-functional teams working intensively to identify and implement targeted changes. In contrast, continuous Kaizen culture reflects an ongoing organizational mindset, where incremental improvements are embedded into daily operations. Distinguishing these modes is crucial, as AI integration affects their design, execution, and strategic outcomes differently.

This review bridges that historical foundation with the emerging landscape of Industry 4.0, where Kaizen is being reimagined through technologies like artificial intelligence (AI), the Internet of Things (IoT), and process mining (Gomaa, 2025; UNIDO, 2023). The convergence of Artificial Intelligence (AI) and Kaizen practices has emerged as a strategic frontier for continuous improvement. Organizations now face the challenge-and opportunity-of integrating intelligent systems into traditionally human-centered methodologies. These tools help detect inefficiencies, automate insights, and speed up decision-making, transforming continuous improvement practices.

2. Methodology of the Review

This narrative review synthesizes insights from peer-reviewed research, practitioner manuals, and empirical studies published between 2018 and 2025, with a focus on how Kaizen events are evolving through the integration of artificial intelligence (AI) and Industry 4.0 technologies. Keywords used included: "Kaizen AND Artificial Intelligence", "Lean manufacturing AND AI", "Continuous improvement AND digital transformation", "Industry 4.0 AND organizational development" and "Human-centered leadership AND AI". Sources were selected based on the following criteria: 1) relevance to Kaizen, Lean, or continuous improvement practices 2) integration or discussion of AI technologies or digital enablers and 3) focus on organizational development, leadership, or human factor. The selected literature was analyzed using thematic coding to identify recurring concepts, challenges, and opportunities. Themes were grouped into four domains: 1) human-centered leadership and psychological enablers 2) AI-enabled decision support and automation 3) emotional dynamics and change management 4) strategic alignment with Industry 4.0/5.0 principles.

To deepen the methodological lens, this review also considers the role of digital twins-virtual replicas of physical systems that simulate real-time operational dynamics-as a practical AI-enabled mechanism for Kaizen experimentation. Digital twins allow teams to test proposed process changes within a controlled digital environment prior to physical execution, aligning with the Plan-Do-Check-Act (PDCA) cycle by enabling predictive validation, rapid iteration, and risk mitigation. Their inclusion reflects a shift toward intelligent experimentation, where human insight and machine learning coalesce to drive sustainable organizational development. This tool-based perspective complements the thematic domains by offering a tangible interface between AI analytics and continuous improvement practice.

These themes informed the development of the conceptual framework presented in Figure 1. The goal is to lay the groundwork for a forward-looking model that reimagines Kaizen implementation in the context of AI-enhanced Lean manufacturing. To provide historical depth, the review also draws on Bhamu and Sangwan's (2014) comprehensive analysis of Lean literature, offering a foundational lens through which Kaizen's role within Lean ecosystems can be better understood (Franken, van Dun, & Wilderom, 2024; UNIDO, 2023).

Framework Selection and Relevance

This study integrates Kaizen, Lean, Digital Kaizen, the Sustainable Innovation Framework, and Neutrosophic Cognitive Mapping to examine AI-enabled organizational transformation. Kaizen and Lean provide the foundational logic for continuous improvement and waste reduction. Digital Kaizen extends these principles into real-time, data-driven environments, aligning with AI's adaptive capabilities. The Sustainable Innovation Framework ensures strategic alignment with long-term environmental and social goals, while Neutrosophic Cognitive Mapping offers a tool for modeling uncertainty and stakeholder complexity. Together, these frameworks support a multi-dimensional analysis of change management, innovation, and resilience in the context of Industry 5.0.

Evolution Of Kaizen In The Digital Era

Kaizen, traditionally rooted in incremental, human-driven improvement, has undergone a significant transformation in response to digital disruption. Once reliant on physical observation and manual feedback loops, its principles now intersect with real-time data analytics, machine learning, and cloud-based collaboration tools. This shift is not merely technological. It redefines the very understanding of improvement. Classic kaizen models typically progress through four phases: preparation, analysis, implementation, and sustainment-with leadership and teamwork serving as essential enablers (Franken et al., 2024). Bhamu and Sangwan (2014) argue that Kaizen should be understood as an integral component of a comprehensive Lean system, rather than as a standalone initiative. Emerging discourse on "Kaizen 4.0" highlights the integration of artificial intelligence (AI) and digital twins into these phases to enhance problem-solving capabilities (Gomaa, 2025).

While the core ethos of Kaizen remains intact-continuous, participatory refinement-the mechanisms have evolved. Digital Kaizen introduces algorithmic monitoring, predictive maintenance, and automated reporting, which can accelerate feedback cycles but also risk diluting human judgment. Organizations implementing Lean in tandem with Industry 4.0 technologies-such as the Internet of Things (IoT), real-time data analytics, predictive modeling, and robotics-are achieving synergistic improvements in continuous flow, Kanban systems, and total productive maintenance (Rinaldi et al, 2021). The democratization of data empowers frontline workers with insights previously reserved for analysts, yet it also demands new competencies in data literacy and digital navigation.

For instance, IoT infrastructures and big data analytics facilitate real-time decision-making and equip employees with actionable insights to drive continuous improvement. Robotics and cyber-physical systems enhance standardized work and improve error detection, thereby reinforcing Lean principles at scale. However, Rinaldi et al. caution that while the advantages of Lean are well documented, the performance outcomes of Industry 4.0 tools remain less predictable. This highlights the imperative for Kaizen in the digital era to strike a balance between technological advancement and human-centered approaches-ensuring that digital transformation not only streamlines operations but also fosters learning, adaptability, and sustainable improvement.

Rahardjo, Wang, Lo, and Chu (2022) introduce the Sustainable Innovation Framework (SIF), serving as a "bridge" which aligns Lean Six Sigma methodologies with the principles of Industry 5.0. Their research underscores the importance of human-centricity, sustainability, and resilience, expanding traditional Lean tools to include intelligent autonomous maintenance, zero-defect manufacturing, and perfect one-piece flow. By positioning Lean Six Sigma as a catalyst for human–machine collaboration, their case study illustrates how Kaizen can evolve into a Lean 5.0 paradigm-one that not only minimizes waste across the value stream but also promotes creativity, personalization, and sustainable innovation. Demonstrable improvements in defect reduction and cost efficiency highlight the practical viability of integrating Lean, Kaizen, and Industry 5.0 within a cohesive framework.

Recent scholarship further advances this transformation within the context of Industry 5.0, where the focus shifts from automation to the human-centric integration of advanced digital technologies. Bajic et al. (2023) propose the concept of digital Kaizen, which harnesses human–cyber–physical systems (HCPS) and the Artificial Intelligence of Things (AIoT) to augment human capabilities rather than supplant them. This paradigm shift repositions Kaizen as both a technological and cultural conduit between Industry 4.0 and Industry 5.0, reinforcing its role in fostering inclusive, adaptive, and innovation-driven environments.

Recent applied research continues to demonstrate how artificial intelligence (AI) can enhance Kaizen practices. Alarcón and Vázquez (2024) developed a machine learning–driven system using the ML.NET tool to automate the categorization of Kaizen proposals. Their findings reveal that automating this process not only reduces manual workload and improves classification accuracy but also accelerates decision-making and boosts employee engagement through incentive mechanisms. This application of machine learning illustrates the potential of AI to optimize targeted stages within the Kaizen cycle.

In parallel, Rahardjo et al. (2022) emphasize that Lean Six Sigma can evolve into an Industry 5.0 framework, where human-centricity and sustainability are integral to digital transformation. This shift aligns with the emerging concept of Lean 4.0, which positions Kaizen and Lean methodologies as foundational enablers of digital innovation. Rather than displacing human-centered continuous improvement, Industry 4.0 technologies-such as real-time data analytics, predictive modeling, and intelligent

automation-reinforce Lean principles by accelerating decision-making and minimizing waste across supply chains. The integration of Lean principles with Industry 4.0 thus signals both a resurgence of Lean Automation and a strategic pathway toward sustainable competitiveness in the digital age.

Beyond Kaizen's transformation across Industry 4.0 and 5.0 contexts, the broader Lean manufacturing system is undergoing a significant transformation driven by digitalization. Rossini et al. (2021) emphasize that Lean Automation (LA)-the fusion of Lean methodologies with Industry 4.0 technologies-revives earlier attempts to reconcile process efficiency with automation. While traditional Lean Production prioritized waste elimination, operational stability, and human-centered problem-solving, it initially faced challenges in integrating advanced automation technologies.

The emergence of Industry 4.0 has introduced a suite of innovations-including cyber-physical systems, the Internet of Things (IoT), virtual simulations, additive manufacturing, and cloud computing-that offer new avenues to reinforce Lean principles. This is a strategic shift. Industry 4.0 tools make Lean systems more modular, adaptive, and data-informed.

Rossini et al. (2021) provide empirical evidence that organizations implementing both Lean and Industry 4.0 practices experience notable gains in productivity, quality, inventory management, and delivery reliability. Crucially, their findings underscore that successful integration hinges on cohesive bundles of practices and technologies, rather than piecemeal adoption-echoing longstanding concerns in Lean literature regarding fragmented and inconsistent implementation strategies.

Zenozain's (2025) study explored the transformation of Lean practices between 2015 and 2025 through the lens of neutrosophic cognitive mapping, revealing how artificial intelligence (AI) amplifies Lean methodologies via predictive analytics, inventory optimization, and intelligent automation. However, the research also highlights a critical challenge: when workforce training and adaptation lag behind technological advancements, the evolution of Kaizen is constrained. This affirms that Kaizen's progress relies equally on human readiness and digital capability.

This convergence forms the foundation of an emerging socio-technical paradigm known as "Lean Industry 4.0," in which AI contributes not only to operational efficiency but also to quality assurance, predictive maintenance, and intelligent production planning (Powell, 2024). Powell notably advocates for "digitalization with a human touch," echoing Toyota's principle of Jidoka-autonomation infused with human oversight. This perspective suggests that the future of Kaizen must harmonize AI-driven optimization with a deep respect for human creativity, learning, and problem-solving.

In this context, AI complements human input to enhance continuous improvement in continuous improvement. It enables organizations to eliminate waste and reduce costs while simultaneously fostering resilience, promoting sustainability, and strengthening human capital-key pillars in the transition toward Industry 5.0.

These perspectives illustrate that Kaizen in the digital era has transcended its traditional role of localized process improvement. It is now embedded within a broader ecosystem characterized by AI-driven decision-making, digital transformation, and the human-centric principles of Industry 5.0. The evolution of Kaizen reflects a dual trajectory: on one hand, technological augmentation through AI and Industry 4.0 tools; on the other, cultural adaptation that safeguards psychological readiness, continuous learning, and sustainable participation.

Expanding on these insights, Sanders, Elangeswaran, and Wulfsberg (2016) emphasize that Kaizen's transformation in the digital age is inseparable from the rise of Industry 4.0. Their research demonstrates that technologies such as cyber-physical systems, the Internet of Things (IoT), and data-driven integration directly support Lean practices-including just-in-time delivery, pull production, continuous flow, supplier integration, and predictive maintenance. For example, e-Kanban systems equipped with RFID tracking automate inventory replenishment, while predictive analytics improves equipment maintenance and quality assurance. These innovations not only reduce waste and synchronize supply chains but also empower employees by transferring repetitive tasks to smart devices and automated systems.

Sanders et al. (2016) underscore that Industry 4.0 does not merely coexist with Lean-it actively enhances Kaizen's potential for continuous improvement. In this light, Kaizen's digital evolution is best understood as a convergence, where Industry 4.0 technologies serve as enablers of Lean transformation, fostering faster, data-informed, and human-centered improvement cycles.

In short, the digital evolution of Kaizen now includes a suite of operational technologies that support every phase of implementation. During the *preparation phase*, process mining platforms such as Celonis and UiPath analyze enterprise event logs to identify bottlenecks, inefficiencies, and hidden process variants. This allows teams to target high-impact areas before the event begins, replacing intuition with data-driven prioritization.

In the *execution phase*, machine learning models-built using platforms like ML.NET or TensorFlow-support predictive maintenance and anomaly detection. These tools enable real-time monitoring of equipment and workflows, allowing facilitators to intervene proactively rather than reactively. AI-driven proposal categorization systems also streamline the intake and triage of employee suggestions, using natural language processing to group similar ideas, flag urgent issues, and reduce administrative overhead.

The *sustainment phase* benefits from digital twin simulations, which allow teams to model proposed changes in a virtual environment before physical implementation. This reduces risk and improves decision accuracy by visualizing downstream effects. Collaborative platforms such as Microsoft Power BI, Miro, and Trello reinforce

transparency and alignment by enabling real-time data sharing, visual management, and asynchronous feedback loops across distributed teams.

These operational integrations extend the reach of Kaizen events-accelerating cycles, deepening insight, and enabling scalable, adaptive improvement. They also shift the facilitator's role from manual coordination to strategic orchestration, where human judgment is amplified by intelligent systems.

Key Success Factors for Effective Ai-Augmented Kaizen Events

Beyond data readiness and leadership sponsorship, successful implementation in the Industry 5.0 era demands organizational preparedness for human–machine collaboration. Bajic et al. (2023) identify skill development, upskilling, and employee empowerment as critical enablers of digital Kaizen. These elements resonate with traditional Kaizen philosophies while extending them through AIoT-enabled decision-making and human–cyber–physical systems (HCPS) frameworks.

Another key success factor in AI-augmented Kaizen is the seamless integration of automation into routine practices. Alarcón and Vázquez (2024) demonstrate that machine learning can streamline the processing of Kaizen submissions, reducing cognitive load on employees and fostering more active participation. By ensuring accurate categorization and enabling data-driven decision-making, such AI-enabled applications help sustain engagement and enhance the quality of continuous improvement cycles (Gomaa, 2025).

Core success factors include data readiness, human-centered integration, leadership sponsorship, and iterative deployment strategies (Franken et al., 2024; UNIDO, 2023). To sustain digital Kaizen, organizations must also invest in skill development and governance mechanisms (Gomaa, 2025). Bhamu and Sangwan (2014) note that Lean adoption has historically been hampered by fragmented practices and the lack of standardized frameworks-highlighting the importance of structured integration in AI-enhanced Kaizen initiatives. Implementation models and frameworks proposed by Kamble et al. (2021) offer a foundation for addressing these challenges.

Relevant frameworks include the UNIDO Digital Kaizen Playbook, Kaizen 4.0 conceptual models, and process mining integrations. Bhamu and Sangwan's (2014) classification of Lean tools illustrates how Kaizen interconnects with complementary methods such as 5S, Total Productive Maintenance (TPM), and Just-in-Time (JIT). In the digital era, these linkages suggest that AI should be embedded across Lean practices holistically, rather than confined to isolated Kaizen events (UNIDO, 2023; Gomaa., 2025; van der Aalst et al., 2020).

Recent contributions have expanded the role of process mining (PM) as a critical enabler within Kaizen-based implementation frameworks. Samara and Harry (2025) propose a conceptual model that integrates Kaizen's human-centered, employee-driven philosophy with the analytical capabilities of PM. Their framework-structured into four phases: Data Collection, Process Analysis, Kaizen Events, and Continuous Monitoring-demonstrates how PM extracts event logs from hospital information systems, electronic health records, and scheduling databases to generate objective insights into real-world workflows, delays, and inefficiencies. This cyclical interaction between PM and Kaizen establishes a dynamic feedback loop in which data-driven insights continuously inform participatory problem-solving.

Crucially, the study reveals that while PM enhances precision and objectivity in improvement efforts, it does not supplant the collaborative and cultural foundations of Kaizen. By merging staff engagement with evidence-based analysis, the integration improves workflow efficiency, reduces patient waiting times, enhances clinical compliance, and strengthens the sustainability of improvements. In practice, this dual model ensures that continuous improvement balances analytical precision with cultural relevance. (Samara & Harry, 2025; Gomaa, 2023).

Challenges, Risks, And Limitations

In addition to longstanding issues such as data fragmentation and cultural resistance, digital Kaizen introduces a new set of challenges in the context of Industry 5.0. Bajic et al. (2023) identify key obstacles including workforce reskilling, the complexity of integrating advanced technologies, cybersecurity and data privacy concerns, and the difficulty of quantifying return on investment (ROI). Addressing these challenges requires multidisciplinary strategies that combine technical innovation with robust organizational change management.

Automation through machine learning adds further considerations. As Alarcón and Vázquez (2024) note, developing accurate models depends on clean, well-labeled datasets and thoughtful system design to mitigate risks of misclassification. Additionally, incentive structures linked to automated classification systems must be carefully managed to ensure fairness and alignment with organizational objectives. These insights underscore the critical role of strong data governance in supporting AI adoption within Kaizen frameworks (Friend & Malhotra, 2019).

Business Model Implications

The rise of AI is reshaping traditional consulting models that rely on billable hours for labor-intensive analysis. As AI tools can perform data processing and visualization tasks in minutes, clients increasingly expect strategic, senior-level engagement rather than time-consuming junior consultant input. This shift pressures firms to explore alternative pricing models, such as pay-per-use or performance-based fees tied to measurable outcomes. While AI accelerates insight generation, it also diminishes demand for routine consulting services-posing a revenue risk for firms that fail to adapt. To remain competitive, firms must invest in workforce reskilling and adopt responsible AI integration practices that balance automation with ethical considerations and trust-building (Samokhvalov, 2024).

Persistent challenges include data fragmentation, cultural resistance, interpretability of AI systems, and long-term

sustainability (Kamble et al., 2021; Franken et al., 2024). Historical Lean research has also pointed to definitional ambiguity and inconsistent adoption of Lean tools (Bhamu & Sangwan, 2014)-issues that remain relevant as organizations seek to standardize AI-augmented Kaizen practices (Friend & Malhotra, 2019).

Kaizen implementation goes beyond technical procedures. It is deeply influenced by psychological factors that influence how individuals and teams perceive, engage with, and sustain continuous improvement. Friend and Malhotra (2019) identify key psychological barriers such as cognitive biases, affective responses, and motivated reasoning that can obstruct collaborative problem-solving. For instance, fixed-pie perceptions, loss aversion, and limited perspective-taking may prevent employees from viewing Kaizen as a mutually beneficial process. Likewise, emotional barriers such as fear, mistrust, and resistance to change can dampen participation in improvement initiatives. These dynamics help explain why Kaizen efforts often falter when psychological readiness is neglected.

Within organizational settings, these barriers manifest as resistance to change, skepticism toward management-led initiatives, and entrenched routines that favor the status quo. Overcoming such challenges requires activating psychological enablers-including empathetic leadership, trust-building, inclusive participation, and framing Kaizen as a shared opportunity rather than a top-down mandate. Drawing from change management psychology, successful Kaizen adoption hinges on reducing perceived threats, fostering a sense of ownership, and cultivating environments that support positive affect and intrinsic motivation. Embedding these psychological considerations into Kaizen 4.0 and Digital Kaizen frameworks ensures not only technical efficacy but also cultural and emotional resilience.

Consequently, AI-enhanced Kaizen should integrate cognitive insight with emotional awareness. While automation-as illustrated by Alarcón and Vázquez (2024)-can alleviate cognitive load, sustaining a Kaizen culture demands attention to the deeper psychological factors cataloged by Friend and Malhotra (2019). By integrating technological capabilities with psychological insight, organizations can reduce resistance, enhance collaboration, and reinforce the long-term impact of continuous improvement initiatives (Gomaa., 2025; Olusegun, 2018).

Beyond technical and organizational challenges, Kaizen implementation in the digital era must also contend with fundamental human-centered risks. Montemayor et al. (2022) argue that empathy presents an inherent limitation for artificial intelligence, particularly in care-related contexts. While AI can simulate cognitive empathy-the ability to recognize and represent emotional states-it lacks the capacity for emotional and motivational empathy. This distinction is especially critical for Lean and Kaizen practices, where success hinges not only on process optimization but also on human engagement, trust, and psychological safety. If AI tools are deployed without acknowledging their inability to authentically empathize, organizations risk cultivating a pseudo-empathetic environment that erodes intrinsic motivation, participatory culture, and confidence in leadership.

Accordingly, the role of Lean practitioners as facilitators of genuine human empathy remains irreplaceable. Their responsibility is to ensure that AI augmentation supports-rather than substitutes-the relational and emotional dimensions of Kaizen initiatives. In practice, this involves embedding AI in ways that alleviate cognitive load while reinforcing leadership empathy, inclusive participation, and authentic human concern, all of which are essential to sustaining continuous improvement (Gomaa, 2025).

Additional limitations stem from AI's inherent difficulty in accurately interpreting emotional complexity. Finet, Kristoforidis, and Laznicka (2025) demonstrate that while AI systems can reliably detect dominant emotional patterns such as fear, sadness, or hope, they struggle with subtle, mixed, and context-specific emotional nuances. Their study reveals inconsistencies across AI platforms and highlights the risk of "emotional hallucinations," where algorithms assign emotional labels that do not reflect actual human experiences. This lack of uniformity poses significant challenges in organizational settings where emotional precision is vital-such as healthcare, negotiation, and team collaboration. The authors advocate for hybrid models in which human interpretation validates and complements automated analysis, thereby mitigating the risks of oversimplification and misrepresentation in emotionally sensitive contexts.

In the context of AI-augmented Kaizen practices, this limitation highlights the irreplaceable role of human practitioners in interpreting emotional cues during improvement initiatives. Overreliance on AI for sentiment or emotion analysis risks generating inaccurate conclusions, eroding trust, and compromising psychological safety among employees. Finet et al. (2025) emphasize that sustainable Kaizen depends on striking a balance between algorithmic efficiency and the nuanced, empathetic judgment that only human facilitators can offer.

The Psychology Of Kaizen Implementation

These findings guided the development of a conceptual framework, illustrated in Figure 1-that demonstrates how psychological enablers (Friend & Malhotra, 2019; Elias, 2009; Olusegun, 2018), human elements (Pour et al., 2024), mediation mechanisms (Munduate et al., 2022), and digital enablers (Alarcón & Vázquez; Bajic et al., 2023; Gomaa, 2025; van der Aalst et al., 2020) collectively shape the effective implementation of Kaizen initiatives within Industry 4.0 and Industry 5.0 environments.

Additional insights into the psychological dimensions of Kaizen can be drawn from leadership and conflict management research. Pour, Bakhshi Zadeh, and Barati (2012) conducted an empirical study examining the relationship between management styles and conflict resolution strategies across various industries. Their findings indicate that relationship-oriented leadership is strongly correlated with solution-focused conflict management, whereas task-oriented styles exhibit weaker or negligible associations. Leaders who prioritize interpersonal

relationships tend to foster supportive climates, navigate the tension between employee autonomy and organizational efficiency, and resolve conflicts constructively-thereby cultivating a culture conducive to continuous improvement.

This highlights that successful Kaizen implementation requires more than technical systems and AI augmentation; it also demands leadership approaches that promote collaboration and constructive conflict resolution (Pour et al., 2012). The alignment of psychological readiness, leadership style, and conflict management strategy forms a critical foundation for embedding Kaizen practices in a sustainable, human-centered manner.

Extending the psychological basis of Kaizen further, Elias (2009) emphasizes that employee commitment during organizational change is significantly influenced by attitudes toward change. Employees with positive perceptions are more likely to support and engage in continuous improvement efforts, while negative attitudes can hinder progress-even when robust technical systems are in place (Gomaa., 2025). Within Kaizen contexts, this highlights the importance of actively cultivating commitment by framing improvement initiatives as mutually beneficial for both employees and the organization.

Olusegun (2018) identifies resistance to change as a persistent psychological barrier within organizational settings. This resistance often arises from fear of uncertainty, perceived loss of control, and mistrust toward leadership. In the context of Kaizen initiatives, such resistance may manifest as reluctance to adopt new processes or skepticism regarding managerial intentions. Addressing these challenges requires targeted psychological strategies-including transparent communication, inclusive participation, and employee empowerment-to alleviate fear and foster a sense of ownership. When considered alongside the insights of Friend and Malhotra (2019) and Pour et al. (2012), it becomes evident that leadership style, conflict management, employee attitudes, and resistance collectively shape the psychological climate in which Kaizen is implemented.

Building on these perspectives, Munduate, Medina, and Euwema (2022) underscore the value of workplace mediation as a constructive tool for conflict resolution. They argue that mediation enhances three essential dimensions: efficiency, equity, and voice. Within Kaizen frameworks, mediation offers structured opportunities for employees to articulate concerns and co-develop solutions, thereby reducing psychological resistance and strengthening trust. By promoting fairness and open dialogue, mediation fosters psychological safety-an essential condition for sustained engagement in continuous improvement efforts. Integrating mediation into Kaizen initiatives reinforces the need to address not only technical and procedural challenges but also the relational and emotional dynamics that underpin lasting organizational change (Gomaa, 2025).

Insights from organizational psychology offer valuable perspectives on the challenges of sustaining Kaizen implementation. Fløvik, Knardahl, and Christensen (2019), in a longitudinal study, demonstrated that organizational changes such as restructuring, downsizing, and outsourcing significantly disrupt the psychosocial work environment. These disruptions increase job demands, reduce employee autonomy, create role ambiguity, and intensify role conflict-factors that collectively undermine well-being and erode trust. Their findings emphasize that repeated organizational changes have cumulative negative effects, weakening social cohesion and diminishing employee engagement.

Applied to Kaizen, these insights reveal that continuous improvement is not merely a technical or procedural endeavor but also a psychologically sensitive process. Sustaining Kaizen requires deliberate attention to psychosocial dynamics, including role clarity, supportive leadership, psychological safety, and trust-especially during periods of organizational change. Without these safeguards, Kaizen initiatives risk inducing stress and disengagement rather than fostering meaningful cultural transformation. Fløvik et al. (2019) thus underscore the necessity of embedding psychological resilience into Kaizen frameworks to balance the pressures of ongoing change with employee well-being and motivation.

Building on recent empirical research, the human dimension of Kaizen is further reinforced by two critical factors identified by Franken, van Dun, and Wilderom (2024). First, during the idea generation phase, effective Kaizen events rely on countermeasures being clearly quantified and directly linked to problem indicators. This structured approach not only encourages creativity but also cultivates psychological ownership and motivation, as team members see their contributions tied to measurable outcomes.

Second, in the implementation phase, the role of line managers as champions of Kaizen is pivotal. When supervisors actively support and lead the adoption of improvement ideas, employees perceive organizational legitimacy and backing, which reduces resistance and builds trust. This leadership commitment fosters psychological safety and encourages deeper engagement in the continuous improvement process.

These findings are echoed in Mahmud et al. (2024), whose survey revealed that Kaizen drives performance through key employee-level mechanisms: participatory engagement (employees proposing and executing small improvements), empowerment (greater control over work processes), enhanced communication and cross-functional collaboration, and explicit recognition of contributions. Together, these elements reduce resistance to change, boost motivation, and sustain long-term participation in continuous improvement activities. Collectively, these findings highlight that effective Kaizen implementation depends not only on technical systems but also on psychological factors-particularly participatory idea generation and visible managerial sponsorship. These elements foster human motivation and are closely linked to sustained performance outcomes (Franken, van Dun, & Wilderom, 2024).

3. Conclusion

The evolving perspectives of Kaizen 4.0 and Digital Kaizen illustrate how continuous improvement is being redefined

through the convergence of advanced technologies and human-centric principles. Given this, the Sustainable Innovation Framework proposed by Rahardjo et al. (2022) represents an initial effort to bridge Industry 4.0 and Industry 5.0 within Lean manufacturing. While promising, further research is needed to refine this framework and develop a robust model for AI-augmented Kaizen implementation. This review contributes by outlining a future-oriented approach that adapts Kaizen practices to the realities of AI integration, ensuring continuous improvement remains both technologically advanced and human-centered.

As continuous improvement evolves, artificial intelligence expands Kaizen's analytical capabilities, while Industry 5.0 frameworks emphasize human empowerment, resilience, and sustainability. Bajic et al. (2023) affirm that the future of Kaizen lies not only in digital augmentation but also in cultivating sustainable, human-centric improvement cultures capable of thriving in complex smart manufacturing ecosystems. The integration of machine learning into Kaizen submissions, as demonstrated by Alarcón and Vázquez (2024), exemplifies how AI can be embedded at granular levels of improvement. When considered alongside broader frameworks such as Digital Kaizen (Bajic et al., 2023), these developments suggest a dual trajectory: AI enhances both strategic and operational dimensions of Kaizen. Effective implementation will depend on aligning technical automation with human-centered engagement to fully realize the benefits of AI in continuous improvement.

Importantly, the psychological dimension of Kaizen implementation must not be overlooked. Friend and Malhotra (2019) highlight how cognitive biases and affective reactions can undermine collaborative problem-solving, while Olusegun (2018) identifies resistance to change as a persistent organizational barrier. These insights underscore that psychological factors are equally critical to successful implementation. Integrating AI-driven efficiency with psychological enablers-such as transparent communication, trust-building, inclusive participation, and structured mediation (Munduate, Medina, & Euwema, 2022)-ensures that Kaizen initiatives are not only technically effective but also culturally and emotionally sustainable.

The psychology of Kaizen further emphasizes the critical role of the human element in sustaining continuous improvement. Research by Elias (2009) demonstrates that employees' attitudes toward organizational change significantly influence their willingness to engage with Kaizen initiatives. When change is perceived as supportive and aligned with personal and organizational values, affective commitment increases, strengthening participation in improvement activities. Conversely, repeated organizational changes can strain the psychosocial work environment, heightening stress, job insecurity, and resistance to engagement (Fløvik, Knardahl, & Christensen, 2019). This highlights the need for psychologically safe environments to sustain Kaizen efforts.

The future of Kaizen depends on a balanced approach that integrates digital tools with psychological insight, creating continuous improvement systems that are resilient, adaptive, and deeply human-centered (Gomaa, 2025). While AI extends Kaizen's reach, it does not replace its human-centered foundation. A dual focus on technological augmentation and participatory culture is essential for effective implementation (Kamble et al., 2021; Gomaa, 2025). By addressing historical challenges in Lean manufacturing-such as the lack of standardized frameworks (Bhamu & Sangwan, 2014)-Kaizen 4.0 offers a more structured and integrated roadmap for continuous improvement in the digital age. This review contributes a multidimensional framework that informs both scholarly inquiry and practical implementation of AI-augmented Kaizen events.

4. Future Research

To advance the integration of Kaizen with AI and Industry 5.0 principles, future research should explore several critical areas. First, empirical validation of conceptual frameworks-such as the Sustainable Innovation Framework and Digital Kaizen models-is essential to assess their practical effectiveness across diverse industries and organizational contexts. Longitudinal studies could examine how AI-augmented Kaizen initiatives influence operational performance, employee engagement, and cultural transformation over time.

Second, research should investigate the psychological dynamics of AI-enabled continuous improvement, particularly how cognitive biases, emotional responses, and leadership styles interact with digital tools. Mixed-method approaches combining sentiment analysis, behavioral observation, and qualitative interviews may yield deeper insights into the human factors that shape Kaizen adoption.

Finally, future studies should explore the role of Kaizen in non-manufacturing sectors-such as healthcare, education, and public administration-where continuous improvement is increasingly vital but under-researched. By expanding the scope and methodological rigor of Kaizen research, scholars and practitioners can co-create resilient, inclusive, and adaptive improvement systems for the digital age.

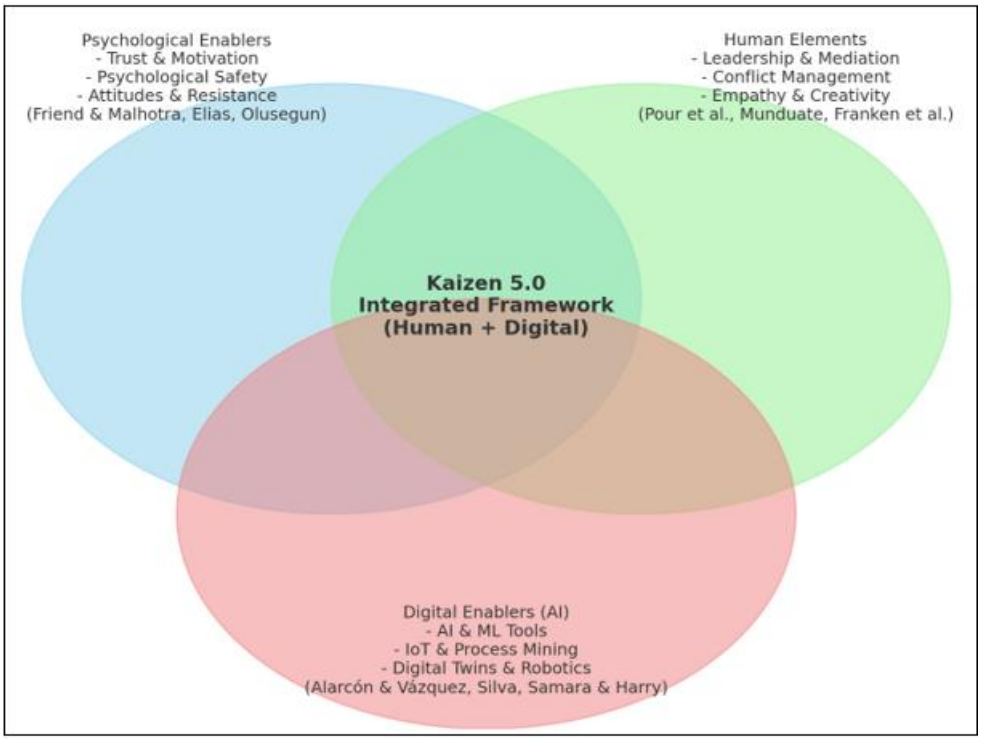

Figure 1: Integrated Framework: Psychological Enablers, Human Elements, and Digital Enablers of Kaizen Implementation

Conflicts of Interest and Informed Consent Declarations: All authors declare that they have no conflicts of interest".

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