SYSTEM SAFETY: HUMAN - TECHNICAL FACILITY – ENVIRONMENT
6(1), 2024, pp. 89-98

TRUST-BUILDING IN AI-HUMAN PARTNERSHIPS WITHIN INDUSTRY 5.0

DOI: 10.2478/czoto-2024-0011
Received: 27/11/2024
Accepted: 05/12/2024

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Abstract: The rapid advancement of artificial intelligence (AI) within Industry 4.0 has transformed manufacturing processes, shifting from traditional automation to more collaborative AI-human partnerships. While AI promises enhanced efficiency, precision, and productivity, the success of these systems relies heavily on the trust established between human operators and AI technologies. This paper explores the critical factors influencing trust in AI-human partnerships in the manufacturing sector, emphasizing the need for transparency, accountability, and ethical AI design. Drawing on a multi-disciplinary literature review and empirical studies, we identify key drivers of trust, including human preferences for system transparency, the explainability of AI decisions, and the reliability of AI systems in dynamic production environments. Furthermore, the paper examines the challenges associated with trust-building, such as overcoming fear of job displacement and managing perceived risks of AI errors. The findings contribute to the growing body of knowledge on human-centric AI design and offer practical recommendations for fostering trust to ensure successful AI-human collaboration in manufacturing settings. By transitioning from purely automated systems to collaborative partnerships, manufacturers can unlock the full potential of AI while maintaining a workforce that is confident in AI's reliability and ethical alignment.
Keywords: artificial intelligence (ai), industry 5.0, human–ai collaboration, cognitive Model of Human-AI

1. INTRODUCTION

The shift towards Industry 5.0 emphasizes the integration of human-centric principles into highly automated and digitalized manufacturing systems. A central challenge is fostering trust between humans and artificial intelligence (AI) to enable seamless collaboration and ensure effective partnerships. While the ongoing adoption of Industry 4.0 technologies has enhanced productivity and system integration (Bao et al., 2022), it has not fully addressed the human-AI interaction complexities necessary for long-term sustainability. This creates a pressing need for novel approaches that prioritize trust, transparency, and adaptability in collaborative environments (Chan-Olmsted, 2019).

Industry 5.0 envisions manufacturing ecosystems where human workers are not replaced but empowered by AI to undertake roles that require creativity, adaptability, and decision-making in increasingly complex socio-cyber-physical systems (Shekhar et al., 2022;

Wang, 2020). However, the challenge lies in designing AI systems that are not only functional but also explainable, reliable, and capable of fostering mutual understanding with human counterparts. Studies suggest that explainability in AI significantly enhances user trust and acceptance, especially in high-stakes industrial applications (Paul et al., 2023; Raisch and Krakowski, 2021).
The concept of trust-building in AI-human partnerships necessitates a multidisciplinary approach, combining advances in AI explainability, immersive learning environments, and human-centric design methodologies (Lim and Zhang, 2022). The scope of this research includes:

- Collaboration Knowledge: Developing frameworks for efficient plant operations (e.g., supervision, quality control, and maintenance) that foster trust and cooperation between human and AI agents (Kim and Kim, 2020).
- AI Explainability: Ensuring AI systems provide transparent and interpretable outputs to enhance user confidence and decision-making capabilities (Gursoy et al., 2019).
- Immersive Learning: Creating learning tools that enable humans and AI to co-develop and adapt to new processes in a shared environment (Dmitrieva et al., 2024).
- Trust Metrics: Establishing measurable indicators of trust within AI-human interactions to guide iterative improvements in collaborative technologies (de-Lima-Santos and Ceron, 2022).
- Ethical Frameworks: Integrating ethical guidelines into AI development to safeguard human agency and reinforce trust (Chen et al., 2021).

The research gap lies in the lack of comprehensive methodologies for fostering trust in AI-human partnerships, especially in diverse industrial and societal contexts. Addressing this gap requires the co-creation of adaptable, sector-independent frameworks that prioritize transparency, reliability, and user empowerment (Broussard et al., 2019). These methodologies must not only enable collaboration in specific industrial settings but also extend their relevance to other societal domains, ensuring a broader impact.
By addressing these challenges, the research aims to develop next-generation AI-driven tools and frameworks that enhance productivity while safeguarding human agency, ultimately advancing the principles of Industry 5.0.
Despite the growing body of literature emphasizing the role of trust in human-AI interactions, there remains a gap in understanding how these principles can be practically applied in real-world manufacturing settings, particularly within the Industry 5.0 framework. While previous studies have highlighted the importance of AI explainability, reliability, and ethical design, there is limited empirical evidence on how these factors are perceived and prioritized by professionals in the manufacturing sector (B. Song et al., 2024). Furthermore, the integration of these trust-building mechanisms into collaborative processes remains an ongoing challenge.
Recognizing this gap, the present study seeks to bridge the theoretical insights with practical applications in the context of Polish manufacturing enterprises. By focusing on the perceptions and experiences of industry professionals, the research aims to uncover actionable strategies for fostering trust in AI-human partnerships. This focus allows for a deeper exploration of the interplay between human and technological factors, paving the way for more resilient and effective collaborations in Industry 5.0 ecosystems (Żywiołek et al., 2024).

To address these challenges, the study poses the following research question: ***What are the key factors influencing trust-building in AI-human partnerships within the manufacturing sector in Poland, and how can these factors be integrated into the framework of Industry 5.0 to enhance collaboration and productivity?***
The primary objective of the study is to identify and analyze the factors that contribute to trust-building in AI-human partnerships in the context of Industry 5.0. Specifically, the research aims to:

1. Examine the perceptions of manufacturing professionals regarding the transparency, reliability, and explainability of AI systems.
2. Identify the challenges and barriers to fostering trust in AI technologies within manufacturing processes.
3. Develop actionable recommendations for integrating trust-building mechanisms into human-AI collaborative frameworks in Industry 5.0.
4. Provide insights into how trust can enhance organizational readiness, collaboration, and productivity while maintaining a human-centric approach in manufacturing environments.

By addressing these objectives, the study contributes to the development of practical strategies for building trust in AI-human partnerships, ultimately supporting the transition to Industry 5.0 in manufacturing enterprises.

2. METHODOLOGY OF RESEARCH

The study employs a survey-based methodology to explore trust-building in AI-human partnerships within Industry 5.0, specifically targeting manufacturing enterprises in Poland. The research aimed to understand the perspectives of industry professionals regarding the factors influencing trust in AI technologies and their integration into human-centric manufacturing processes.
The research sample for the survey was selected using a random sampling method to ensure the representativeness of the results. The study targeted manufacturing enterprises operating in Poland, encompassing various sectors of the industry. The survey was conducted using the CAWI (Computer-Assisted Web Interviewing) method, which allowed for efficient data collection while minimizing respondent bias.
This approach enabled the inclusion of enterprises of different sizes, from small and medium-sized enterprises (SMEs) to large manufacturing companies, providing a comprehensive view of the perceptions and experiences related to AI integration within Industry 5.0 frameworks. The random sampling ensured that all manufacturing enterprises had an equal chance of being included in the study, enhancing the generalizability of the findings to the broader industrial context in Poland.
The target population consisted of manufacturing enterprises operating in various industrial sectors across Poland. A purposive sampling method was applied to select companies actively engaged in digitalization and Industry 5.0 initiatives. The survey was distributed to professionals at different organizational levels, including operators, managers, and decision-makers, ensuring a diverse representation of perspectives.
The survey consisted of structured questionnaires designed to capture qualitative and quantitative data. It included questions related to AI explainability, reliability, user confidence, and organizational readiness for Industry 5.0 transformations. A total of 500

questionnaires were distributed using both online and offline channels. Out of these, 350 valid responses were received, achieving a response rate of 70%.
The questionnaire was developed based on existing literature and expert consultations to ensure relevance and comprehensiveness. It comprised closed-ended questions on a Likert scale (1-5), open-ended questions for qualitative insights, and demographic questions to capture the respondents' backgrounds.
Key sections of the survey included:
- Trust Factors in AI Systems: Measuring perceptions of explainability, transparency, and reliability.
- Collaboration Experience: Exploring current practices in human-AI collaboration.
- Challenges and Opportunities: Identifying barriers and enablers in adopting AI technologies.
- Ethical and Organizational Perspectives: Evaluating ethical concerns and organizational readiness.

The data collected in the study were analyzed using descriptive and inferential statistics. Quantitative data were processed using statistical software, focusing on identifying trends and correlations between trust factors and demographic variables. Qualitative data were analyzed thematically to gain insight into the mechanisms and challenges of building trust. However, the article itself describes preliminary, primary analysis, as these are the first published results from this research.
The high response rate and diversity of participants ensure the findings are robust and representative of the manufacturing sector in Poland. This methodology provides a solid foundation for identifying trust-building strategies in AI-human partnerships and offers practical recommendations for fostering trust within Industry 5.0 frameworks.

3. RESULTS

The Figure 1 presents the results of a survey conducted among employees and business owners regarding the application of artificial intelligence (AI) in the context of Industry 5.0. It highlights the perceived importance of four key factors: colossal personalization, cognitive human-machine cooperation, sustainable development, ergonomics and humanization of work, and production flexibility. These factors represent critical aspects of integrating AI into industrial processes, reflecting both operational priorities and the broader societal implications of technological advancements.

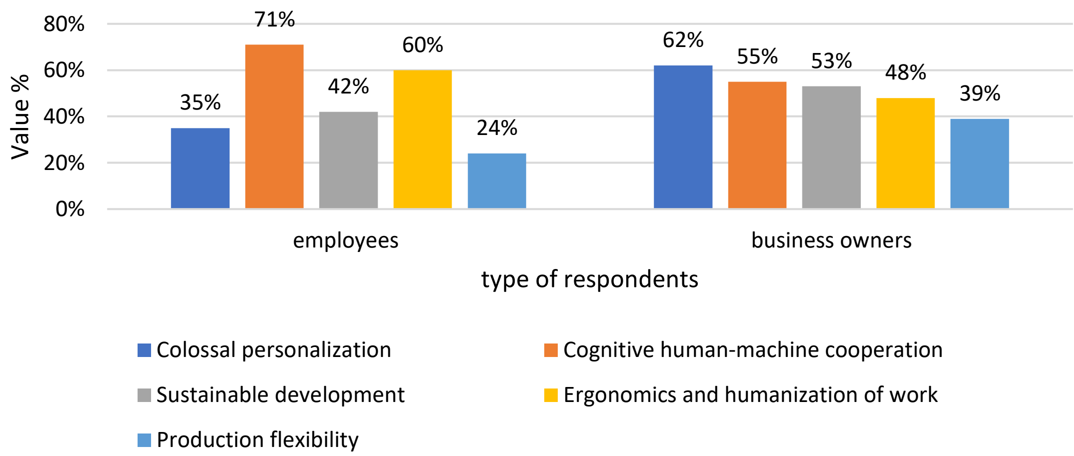

Fig. 1. Prioritization of AI Applications in Industry 5.0 by Employees and Business Owners

The survey results indicate notable differences in the prioritization of these factors between employees and business owners:

1. Employees' Perspective:

a) The most highly valued aspect among employees is cognitive human-machine cooperation, with over 70% identifying this as a priority. This indicates a strong interest in seamless collaboration between AI and human workers to enhance productivity and efficiency.
b) Ergonomics and humanization of work follow closely, with about 60% highlighting its importance. This reflects employees' focus on improving working conditions and fostering a human-centered approach to industrial processes.
c) Sustainable development is considered moderately important, with around 40% of employees recognizing its relevance.
d) Colossal personalization and production flexibility are less emphasized by employees, suggesting that these factors may be perceived as less directly beneficial to their roles.

2. Business Owners' Perspective:

a) For business owners, colossal personalization emerges as the top priority, with nearly 60% emphasizing its significance. This reflects their interest in leveraging AI to deliver highly customized products or services to meet market demands.
b) Cognitive human-machine cooperation and sustainable development are nearly equally important, with over 50% prioritizing these aspects. This indicates a balanced focus on enhancing operational collaboration and addressing broader sustainability goals.
c) Ergonomics and humanization of work and production flexibility are less prioritized, suggesting that these considerations, while relevant, may not align as closely with their immediate business objectives.

The survey results align closely with the cognitive model of human–AI collaboration described in the "Analysis-oriented – Synthesis-oriented" framework. This model emphasizes the dual roles of AI in supporting both analytical and synthetic processes in human-AI partnerships.

For employees, the strong emphasis on cognitive human-machine cooperation reflects their recognition of AI’s analytical capabilities, such as pattern recognition and decision-making support, which can reduce repetitive tasks and improve workplace efficiency. At the same time, their interest in ergonomics and humanization of work aligns with the synthetic dimension of the model, where AI contributes to creating human-centered solutions that enhance job satisfaction and safety.

For business owners, the prioritization of colossal personalization highlights AI’s role in synthesis, where it generates tailored solutions and innovative products to meet diverse customer needs. Their interest in sustainable development and cognitive human-machine cooperation further underscores the importance of AI in balancing extraction (analysis) and integration (synthesis) to achieve both operational excellence and long-term strategic goals.

In conclusion, the results demonstrate how different stakeholders value the cognitive contributions of AI according to their roles and priorities within Industry 5.0. By integrating these perspectives into the cognitive model, we can better design AI systems that address diverse needs, ensuring both productivity and human-centricity in the industrial landscape.

A New Framework for Defining AI Role in Trust, In this section, we propose a new framework that offers a unified and comprehensive classification of AI roles. This framework is divided into three dimensions: 1. Collaboration Initiation Element, 2. AI Usage Scope (General and Cognitive), 3. Trust in AI, which is illustrated in Figure 2.

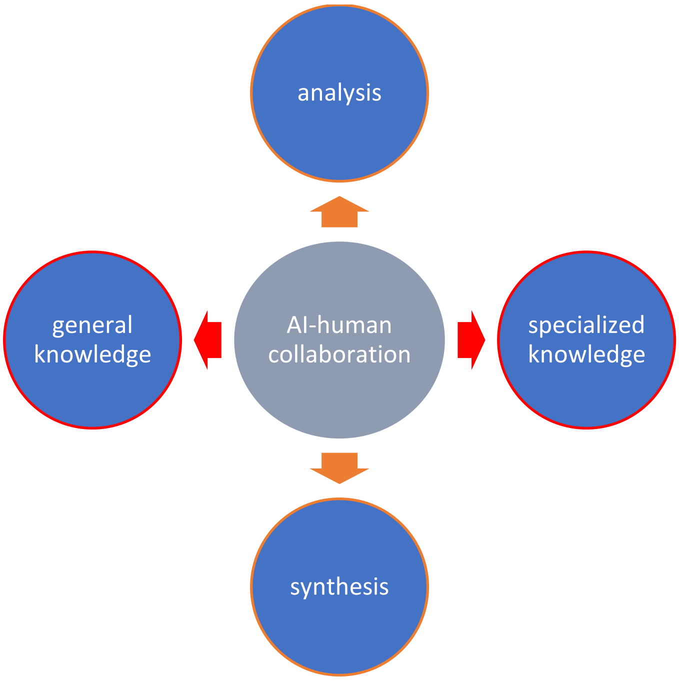

Fig. 2. Proposed AI Role Classification Model for Human-AI Collaboration

The cognitive model of human–AI collaboration, based on the dimension "Analysis-oriented – Synthesis-oriented," highlights the unique and complementary roles of AI and humans in processing and utilizing data for creative or decision-making purposes. This model is structured around two primary aspects: analytical orientation and synthetic orientation. Both play critical roles in facilitating effective collaboration and enhancing outcomes in various domains, particularly in design innovation.

In the context of analysis, AI acts as a tool for interpreting and simplifying complex data. Its tasks include pattern recognition, classification, and the extraction of meaningful insights. For instance, AI can analyze consumer preferences by examining online reviews, a process crucial for understanding user needs (McGrath et al., 2024). Furthermore, AI supports decision-making by retrieving technical knowledge through knowledge-based systems, which provide relevant data in a structured and actionable format (Kamble et al., 2018). Another critical function of AI in analysis is the automatic evaluation of product or prototype performance, ensuring alignment with predefined specifications (Rožanec et al., 2023). Analytical processes predominantly focus on breaking down and organizing complex information into accessible forms, such as patterns, indicators, or labels, which humans can then use to make informed decisions.

In contrast, the synthetic orientation of AI emphasizes the creation and generation of new concepts, insights, or solutions. Unlike analysis, synthesis integrates and enriches data, transforming it into innovative designs and ideas. In design innovation, AI contributes significantly to tasks such as concept generation and shape synthesis, particularly in later stages of the creative process. For example, AI-driven generative design and topological optimization enhance the functional performance of design solutions (Hussain et al.,

2024). More recently, AI has begun to play a role in earlier stages of design, such as generating functional concepts and even developing an empathetic understanding of stakeholders (Żywiołek, 2024a). These advancements broaden the scope of AI's application, enabling it to participate in the ideation process and provide creative support.
The interplay between analysis and synthesis within AI delineates its cognitive orientation: whether it focuses on extracting information or integrating it into new forms. In the collaboration between humans and AI, this distinction allows for a balanced and dynamic approach. Humans take on the roles of supervisors and creators, setting goals and priorities, while also interpreting and adapting the outputs generated by AI. Meanwhile, AI functions as both a processor and a creator, providing analytical insights and contributing to the generation of innovative solutions.
Recent studies exemplify this symbiotic collaboration. Research (Żywiołek, 2024b) demonstrates AI's ability to analyze consumer preferences by processing online data, while Song et al. (M.-K. Song et al., 2013) highlight its capability to evaluate design functionality through automated systems. Schepman et al. (Schepman and Rodway, 2020) discuss generative design's transformative potential, and Zhu (Wang and Zhu, 2021) explore the use of AI to foster empathy and creativity in early design stages. Together, these studies underscore the interdisciplinary nature of human–AI collaboration, emphasizing AI's ability to support logical problem-solving and creative innovation simultaneously.

4. DISCUSSION AND CONCLUSION

The study highlights key findings on trust-building in AI-human partnerships within Industry 5.0. One major conclusion is that while AI-driven systems are highly efficient, their adoption and integration into industrial processes rely heavily on building trust among users. Transparency, reliability, and ethical design of AI systems are crucial in fostering confidence among employees and decision-makers alike.
From a practical perspective, the results underscore the importance of designing AI systems that are not only functional but also user-friendly and explainable. This is particularly relevant for employees who interact with these systems daily. Ensuring that AI tools provide clear and interpretable outputs can reduce resistance to adoption and enhance productivity. Additionally, business owners need to focus on aligning AI technologies with their strategic goals, such as improving customization capabilities and maintaining sustainable practices.
Managerial implications include the need for structured training programs to bridge the knowledge gap between employees and advanced AI systems. Managers must facilitate a culture of collaboration, where both humans and AI are seen as complementary forces rather than competing entities. This can be achieved by introducing frameworks that support transparent decision-making processes and ethical AI deployment. Furthermore, organizations must prioritize ergonomic solutions that enhance the well-being of employees while leveraging AI capabilities to drive innovation.
While the study provides valuable insights, it has several limitations. First, the survey methodology, though effective, may not capture the full complexity of trust dynamics in AI-human collaborations. The focus on the Polish manufacturing sector limits the generalizability of the findings to other industrial or cultural contexts. Additionally, the study primarily relies on self-reported data, which can introduce biases, such as overestimation of positive experiences or underreporting of challenges.

Another limitation is the static nature of the data collected; it does not account for the evolving nature of AI technologies and their impact on trust over time. Longitudinal studies are needed to explore how perceptions of AI reliability and transparency change as users gain more experience with these systems. Finally, the research does not deeply explore the psychological and emotional dimensions of trust, which may be critical in fostering long-term human-AI partnerships.

Despite these limitations, the study provides a robust foundation for understanding trust-building mechanisms in AI-human collaborations. It offers actionable recommendations for improving the integration of AI systems into manufacturing processes while maintaining a human-centric approach. Future research should address the outlined limitations by exploring cross-cultural perspectives, longitudinal trust dynamics, and the psychological underpinnings of AI-human interaction in Industry 5.0.

The integration of artificial intelligence (AI) within Industry 5.0 requires a focus on building trust in human–AI relationships, which is essential for effective collaboration and fully leveraging the potential of new technologies. As highlighted in the literature, trust relies on three key pillars: system transparency, reliability, and ethical design (Kareem Thajeel et al., 2023). The shift from traditional automation to human–AI collaboration in Industry 5.0 assumes that these systems not only support operational processes but also address employee needs for ergonomics and the humanization of work (Li et al., 2023).

The findings reveal that different stakeholder groups—employees and business owners—have varying priorities regarding the use of AI. Employees particularly emphasize the importance of cognitive human-machine cooperation and ergonomics, reflecting their interest in improving working conditions and operational efficiency (M.-K. Song et al., 2013). Conversely, business owners place greater importance on personalization and production flexibility, demonstrating a strategic focus on utilizing AI to achieve a competitive advantage (Gillath et al., 2021).

The limitations of the study include its contextual focus on the Polish manufacturing sector, which may restrict the generalizability of the findings to other countries or industries. Additionally, the study relied on a survey methodology, which does not account for the dynamic nature of evolving technologies and their long-term impact on trust. As suggested by Bitkina (Bitkina et al., 2020) and Langer et al. (Langer and Landers, 2021), future research should explore cross-cultural differences and longitudinal perspectives to better understand the evolution of human–AI relationships.

In conclusion, the study's findings highlight the need for designing human-centered AI systems that consider both organizational and employee needs. Achieving this requires a combination of transparency, reliability, and ethics in technology design, enabling the development of sustainable and productive human–AI partnerships in the era of Industry 5.0.

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