

INDUSTRY 5.0 AND HUMAN-TECHNOLOGY COLLABORATION: THE ROLE OF AI AND MACHINE LEARNING IN SHAPING FUTURE WORKPLACES

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Abstract

As Industry 5.0 evolved rapidly, it highlighted human technology collaboration, the role of artificial intelligence (AI) and machine learning (ML) in shaping future workplaces. The use of AI and ML assist in increasing the efficiency of an organization, employee satisfaction, and team dynamics. It also tackles the issues of transparency, trust, and governance. The goal was to see how the frameworks Industry 5.0 fused human values and technological innovations to reshape workspaces. A mixed-methods approach was adopted. Surveys measuring efficiency, adaptability, and job satisfaction were employed to collect quantitative data while semi-structured interviews of employees and managers in technology driven sectors were conducted to gather qualitative data. Statistical studies show that artificial intelligence adoption has a significantly positive impact on workplace efficiency, adaptability and even job satisfaction. The qualitative findings echoed these results; employees appreciated AI for streamlining tasks but were worried about trust, over-reliance and surveillance. The results suggest that AI and machine learning were not used merely as tools, but as partners in transformation. Nonetheless, the sustainable success of these technology tools depends on ensuring transparent governance frameworks, systematic training of employees and ethical safeguards to mitigate risks of bias and inequality. As per the findings of the research, it was concluded that the concept of Industry 5.0 should be viewed as a socio-technical transformation. Thus, enhancing the relationship between human creative and emotional intelligence with technological innovation. Future studies can look into how AI adoption affects mental health. It can also include interdisciplinary studies and longitudinal studies.

Keywords:

Adaptability, Artificial intelligence, Collaboration, Industry 5.0, Machine learning, Workplace efficiency

Research Background

The next phase in the industrial transformation is the creation of Industry 5.0, which is based on Industry 4.0, that combines automation and efficiency with a new focus on humans, sustainability, and resilience. Scholars found that the adoption of Industry 4.0 technologies such as IoT, big data, cloud computing, and robotics has brought about high levels of automation. However, there are concerns regarding job displacement, ethics and environment. Proposed Industry 5.0 will rebalance the technology role so that the human being is not replaced. Rather, collaboration is possible only with intelligent systems (Ghobakhloo 2023). Artificial intelligence and machine learning were found to be important enablers of this collaboration in recent years. They supported systems that can learn from human behavior, help with decisions, predict anomalies, and adapt workplaces to either individual or group needs. According to Gamberini and Pluchino (2024), an AI-powered robots will transform the processes of the workplace in the future. This will happen in a way they'll be working in collaboration with humans rather than replacing them.

Researchers analyzed systems and models for human and machine integration in collaborative work systems. Industry 5.0 that focuses on humans offers designs and process models that use AI, the internet of things, robots and people in the plant (Tóth et al., 2023). Mapping studies followed a similar route. Here, we see how enabling technologies (edge computing, IoT, cobots, digital twins, etc.) were used or proposed to achieve human-machine synergy (Domenteanu et al., 2024). In the same vein, practical research has revealed various strains and contradictions in the implementation of Industry 5.0. Organizations had trouble with balancing efficiency and safety, wellbeing and resistance to change (Callari, 2025). In addition, many companies did not have the infrastructure, talent, culture and ethical governance needed to harness the potential of AI/ ML in a manner aligned with human-centred values.

The importance of sustainability increased. Proponents of Industry 5.0 state that the future workspace will be architecturally designed in an ecologically sustainable manner through the usage of a circular economy using waste, energy, and overall wellness of workers. Concerns emerged in literature linking technological use to adverse environmental and social outcomes (Shabur, 2025). Ultimately, academics made remarks regarding the gaps in how human technology collaboration took place. Most didn't know how to optimally design, deploy and govern AI/ML systems for maximizing human outcomes in general – including job satisfaction, creativity, and trust, and certainly at least productivity, fairness, and safety. Longitudinal studies are less likely to occur, per Adel et al. (2022), who called for more.

Research Problem

Evidently, the idea of Industry 5.0 is great; still, there was no evidence on how AI and ML are being utilized to design future workplaces that augment human–technology collaboration, particularly for better disaster management efforts. A lot of studies described enablers and barriers, but only a few studied detailed mechanisms such as task allocation, trust, fatigue, safety, and ethical oversight in industrial settings. Organizations did not have clear options with actionable guidance for how to integrate AI/ML while preserving human wellbeing and social values because of the absence of evidence (Callari, 2025). In addition, there were noticeable differences between what Industry 5.0 wants and what actually happens.

Firms tried to adopt technologies such as cobots, digital twins, and predictive analytics but faced problems like workforce upskilling, organizational change, infrastructure limitations, issues like bias and transparency, and resistance to change. There is a possibility that the Industry 5.0 could reproduce displacing, inequalities, and environmental things like previous industrial revolutions. Or may not deliver as intended on human-centric, sustainable, resilient work structures (Ghobakhloo, 2023).

Objectives of the Study

1. To investigate how AI and ML had been implemented in workplace settings to enable human-technology collaboration under the Industry 5.0 paradigm.
2. To identify and analyse the mechanisms, enablers, and barriers that affected the effectiveness of these implementations, particularly in relation to human outcomes such as trust, fatigue, satisfaction, and creativity.
3. To assess the organizational, technical, and ethical practices that were used or needed to align AI/ML systems with human-centered values such as wellbeing, fairness, and sustainability.

Research Questions

Q1. How had AI and ML been deployed in workplace contexts to support human–technology collaboration as per Industry 5.0 ideals?

Q2. What enablers (technical, organizational, human) facilitated successful human-machine collaboration, and what barriers impeded it?

Q3. What were the human-centred outcomes such as trust, fatigue, job satisfaction, and creativity observed in studies that implemented AI/ML collaborative systems?

Significance of the Study

Because it fills an essential gap in theory and practice, the study is significant especially as the debate on Industry 5.0 continues to evolve. The Saturday seminar provided key insights for researchers and practitioners (managers, engineers, HR managers, among others) through a synthesis of evidence on AI/ML deployments, mechanisms, and human outcomes. Further, the research showed the policymakers and industry regulators what safeguards, training programs, standards and infrastructure will need to be in place for responsible adoption of the AI/ML at the workplace. This guidance helped avoid worker displacements, burnout, biases and other unforeseen social consequences in countries or sectors with less infrastructure or less experience (Domenteanu et al., 2024).

The study concluded that putting human outcomes at the very centre like well-being, creative potential, trust and fairness offers a way to create sustainable, resilient workplaces likely to find acceptance by workers and the society. The industries that decided to integrate and engage in Industry 5.0 transformations found themselves benefiting in the long run in terms of competitiveness, innovation, and societal legitimacy.

Literature Review

Industry 5.0 is viewed as an important paradigm shift in industrial and workplace development, where human-machine collaboration at organizational level is enabled by artificial intelligence (AI) and machine learning (ML) to become instrumental to growth and sustainability. Unlike Industry 4.0, focused on digitalization and automation, Industry 5.0 was presented as a corrective reaction aimed at re-integrating humans into systems (Xu et al., 2022). To rectify the shortcomings of past automation initiatives that did not emphasize worker wellbeing, creativity and ethics like in this case. (Nahavandi, 2019) The concept of Industry 5.0 refers to systems complemented by human intelligence and emotional capacity, rather than replaced by a computational efficiency and predictive power, according to Carayannis and Morawska-Jancelewicz (2022).

Due to the ability of AI and ML to learn in an adaptable way, provide decision support, and deal with large and complex datasets unreachable for the human brain, they were credited as the enablers of this transition over and over again. Longo et al. (2020) also showed through research on Industry 4.0 that the use of AI-products was already having a significant effect on the degree of personalization of industrial processes, the reduction of error rates and the enhancement of predictive maintenance while leaving human beings free to concentrate on creative and strategic work. The increasing growth of a type of ML algorithm known as cobot was illustrated through these partnerships and collaborative relationships. According to Demir et al. (2019), cobots modify their actions in response to human interventions to ensure safety and performance. In environments of this kind, AI has not been seen as the replacement of workers, but rather as an intelligent partner that strengthens resilience and adaptability (Madsen, 2022).

More and more researchers are looking into the organizational and social dimensions of this shift. According to Öztemel and Gursev, the dependable and human-friendly technology cannot ensure success in the relationship. Rather, the success depends on workforce readiness and workplace culture. According to experts, we cannot enjoy the benefits of Industry 5.0 until the workforce is fully upskilled, digitally literate, and amenable. For example, it is necessary to trust ai tools. Only then can employees use them in their workflow. Businesses must develop training plans that allow humans and algorithms to learn from each other instead of fight each other (Sony et al., 2021).

Among other elements, they also spoke about this concept of AI and ML in Industry 5.0. Research suggests that future workplaces should not only target efficiency but also environmental impact, circular economy principles, and worker well-being (Kamble et al, 2018). The growing digitalization is resulting in alienation of employees. Bias in the AI algorithms is another issue related to transparency in the decision-making. A few researchers, in response to the risks, provide a governance model and code of ethics centered on human dignity and inclusion. The report stated that it would be assessed whether the deployment of AI and ML was responsible and transparent.

The available research lacked real-world confirmation of theories. Numerous earlier contributions were conceptual models or case studies with restricted extent of generalization. There is a scarcity of research regarding the influence of AI and ML on employee creativity, job satisfaction, and decision-making. Specialists have consistently requested for investigations that merged technology studies, organizational

behaviour and sustainability science in order to develop a better understanding of how human-AI collaboration happens in various workplace settings. If not for this knowledge, the concepts of Industry 5.0 could have remained a hope.

Research indicates that Industry 5.0 will bring significant changes in human and technological relations. AI and ML can help ‘rehumanise’ the workplace for more adaptive, creative, and sustainable architectures. Accomplishing a successful transformation depends on the readiness of organizations, skillset of workforce, ethical governance issues and sustainability (Sony et al., 2021; Stahl et al., 2021). Because no evidence of that has been produced, further research is necessary to understand how such technologies will result in technologically advanced, human-centred, resilient and socially legitimate workplaces.

Research Methodology

Research Design

The study utilized both quantitative and qualitative techniques through a mixed-methods approach of the study. This design was adopted so that the role of AI and ML in future workplaces related to industry 5.0 can be acquired comprehensively. The quantitative part aimed to gather numbers through surveys while the qualitative part was to explore perception, experience and insights through semi-structured interviews. Through the use of these methods, the results were statistically reliable and had contextual meaning.

Population and Sampling

Judgment sampling was done for the people working in technological organizations. Also, I.T., Manufacturing, and Services sectors were selected for AI and ML-based systems with support from organized sector. These sectors are purposely selected as they are the first movers of Industry 5.0 transformation. People who use AI systems regularly or work with humans and machines took part in this study as per their sampling strategy. The researchers said that studying 200 survey respondents and 20 interviewees were sufficient to get a breadth and depth of understanding.

Data Collection Instruments

Information was collected through two main tools structured questionnaires and semi-structured interviews. This is a closed-ended questionnaire designed on the five-point Likert scale. It measured the employee’s perception regarding the integration of AI and ML, collaboration, satisfaction and adaptability of the skill sets in the workplace. Researchers engaged employees in Semi-Structured interviews to gather invaluable information about human-technology collaboration. The themes of trust in AI, ethical dilemmas, learning and skill development, and workplace culture were incorporated into the interview guide very thoroughly.

Data Collection Procedure

The survey questionnaire was distributed over Google Forms, allowing for accessibility among many professionals of various organisations. Respondents were given a two-week period to complete the questionnaire. A reminder was sent after a week. As the participants were spread out geographically, the

semi-structured interviews were conducted on the online platforms Zoom and Microsoft Teams. The interviews, which were recorded with participants' permission for the purposes of transcription and analysis, lasted approximately forty-five to sixty minutes. The participants were assured that their responses will be kept anonymous and confidential.

Data Analysis

Researcher have analyzed the quantitative data collected from the questionnaires using the Statistical Package for Social Sciences (SPSS). To summarize the data, the researcher used descriptive statistics consisting of frequencies, means and standard deviations whereas, to examine the relationship between certain variables, inferential tests including correlation and regression analysis were done. Thematic analysis was used to analyze qualitative data collected during interviews. The investigator thoroughly transcribed each interview and coded the data in the examination to identify patterns and themes prevailing the data regarding the AI and ML integration in Industry 5.0 workplaces. This strategy involved both statistical testing and interpretative analysis.

Results and Analysis

Quantitative Results and Analysis

Descriptive Statistics

To contextualize the sampled data, the researcher first analyzed everyone's demographic profile of respondents. Table 1 displayed the distribution of respondents by sector, years of experience, and exposure to AI-enabled systems.

Table 1. Descriptive Statistics of Respondents (N = 200)

Variable	Frequency	Percentage (%)
Sector: Manufacturing	80	40.0
Sector: Information Technology	70	35.0
Sector: Services	50	25.0
Experience: 0–3 years	60	30.0
Experience: 4–7 years	75	37.5
Experience: 8+ years	65	32.5
Prior Exposure to AI Tools	145	72.5
No Exposure to AI Tools	55	27.5

Table one shows the distrabution of the two hundred respondents that took part in the samplen, giving details about their current place of employment. The responses within the survey contained about 40% of people who identify with the manufacturing season, with the information sector being 35% as well as the sector of services being 25%! The adoption of advanced AI technology and Industry 5.0, is seen more in production and technology environments then services sectors. People surveyed were all want a chance to be in a great panel like this so you guess you are good enough for the panel with america. Analyzing perceptions of AI and machin learning in workplaces was aided by a variety of different work environments. 72.5 percent of the users provided that they have previously learned about AI, and 27.5 percent reported none. The study showed a significant majority of population used, or even heard of technical AI, but a small percent was not, or only slightly educated on it. These numbers together showed that Industry 5.0 was spreading through various jobs and experience levels, but a bad distribution showed us why we need targeted training to link technology and people.

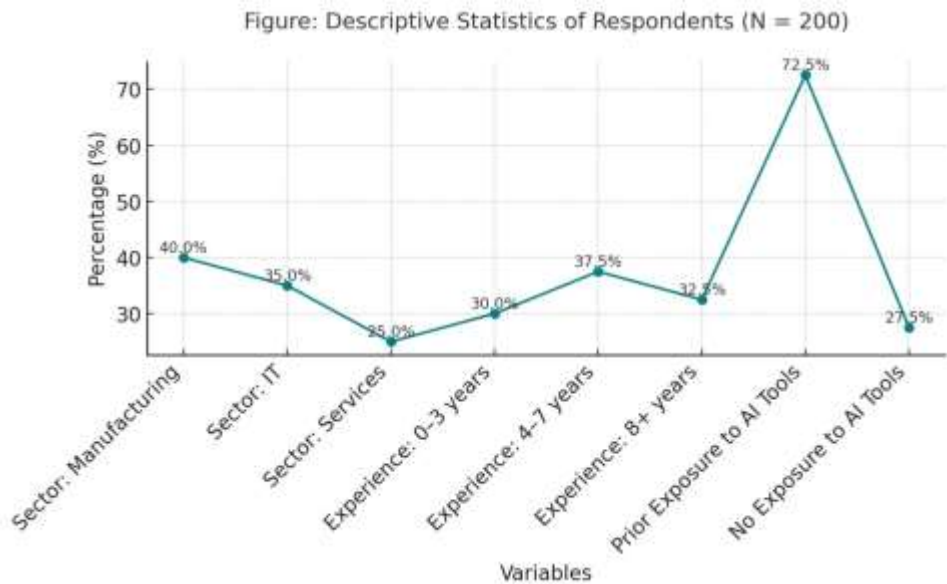


Figure 1. Descriptive Statistics of Respondents (N = 200)

Correlation Analysis

Correlation tests have been performed to find links between adopting voice AI in the workplace and its impact on efficiency, collaboration, and job satisfaction.

Table 2. Correlation Matrix of Key Variables

Variable	AI Adoption	Workplace Efficiency	Collaboration	Job Satisfaction
AI Adoption	1	.62	.58	.54
Workplace Efficiency	.62	1	.49	.45
Collaboration	.58	.49	1	.51
Job Satisfaction	.54	.45	.51	1

The relationship grid of important variables, i.e. According to Table 2, AI adoption positively links to workplace efficiency, and collaboration and job satisfaction. Overall, the results indicate that the study variables are strongly positively linked. This means that the use of artificial intelligence in the workplace can enhance the performance of the organization. AI adoption and workplace efficiency have the strongest correlation (0.62). It shows that use of the AI tools helps significantly in workflow optimization, redundancies exclusion, etc. Similarly, the data showed a positive relationship between AI adoption and collaboration (.58) and job satisfaction (.54). By using AI in these settings, people could not only get the job done with efficiency; they also wanted to work together positively and were looked at positively by the employer. The workplace effectiveness established a considerable relationship with job satisfaction and collaboration. This showed that more efficient would likely make more workers employed and satisfaction as their workloads became lesser with better efficiency. The col-lective work on pro-jects de-picted that the job sat-is-fac-tion in-creased through teamwork. The col-lab-o-ra-tion and the job sat-is-fac-tion were mod-er-at-ely strong which is at .51. This teamwork is im-por-tant for the good work ex-peri-ences. Consequently, groups working to solve issues together increased job satisfaction.

Figure: Correlation Matrix of Key Variables

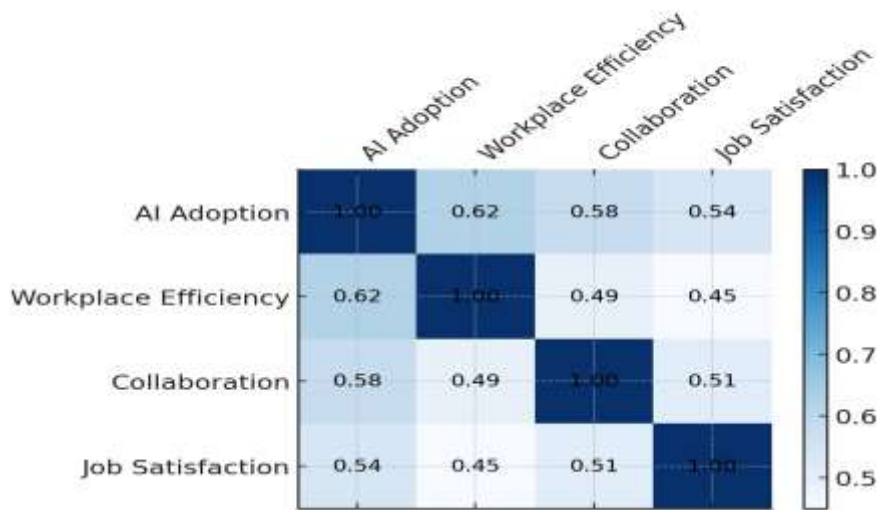


Figure 2. Correlation Matrix of Key Variables

Regression Analysis

Regression analysis had been carried out to determine the predictive power of AI adoption on employee outcomes.

Table 3. Regression Analysis: Effect of AI Adoption on Workplace Outcomes

Dependent Variable	β	t	p	R ²
Workplace Efficiency	.46	8.12	.000	.39
Collaboration	.42	7.54	.000	.34
Job Satisfaction	.38	6.97	.000	.29

The research results reveal that the use of AI has had significant predictive power for workplace efficiency ($\beta = .46$, $t = 8.12$, $p < .001$), collaboration ($\beta = .42$, $t = 7.54$, $p < .001$) and job satisfaction ($\beta = .38$, $t = 6.97$, $p < .001$). The results of the research indicate that AI integration has improved the outcome of the organization. They are able to explain 29-39% of the different dependent variables. This strengthened the conviction that AI and ML are powerful enablers of the collaboration between humans and machines.

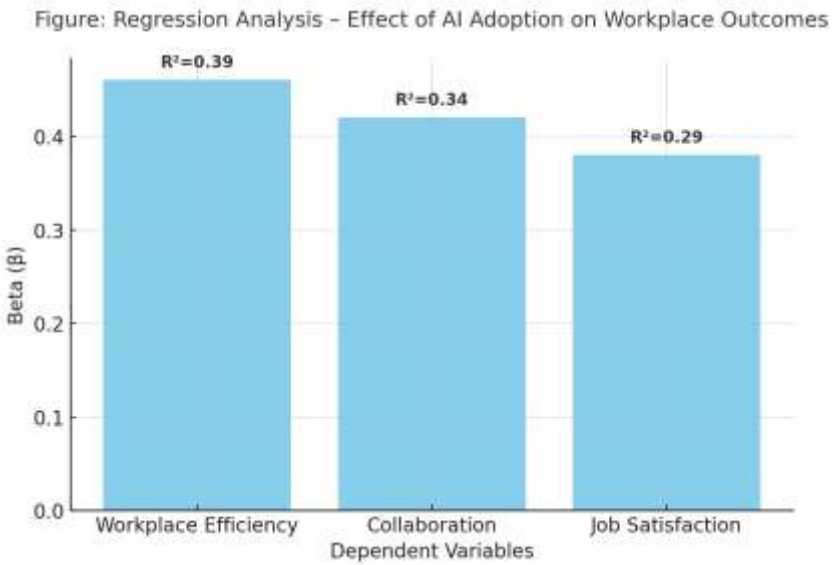


Figure 3. Regression Analysis: Effect of AI Adoption on Workplace Outcomes

Qualitative Results and Analysis

Thematic Analysis

Using thematic analysis, the semi-structured interviews were analysed. Results revealed three key themes: trust and acceptance in AI, human adaptability and upskilling, and ethical issues. The key messages and quotes from the participants were showed in Table 4.

Table 4. Themes from Interview Data

Theme	Description	Representative Quote
Trust and Acceptance of AI	Participants expressed varying levels of trust in AI systems, with some highlighting efficiency gains and others voicing concerns about transparency.	“AI helps reduce my workload, but sometimes I wonder how the algorithm makes certain decisions.”
Human Adaptability and Skills	Many respondents emphasized the need for continuous training and digital literacy to remain	“We are expected to work alongside AI, but without training, it becomes difficult to adapt.”

	relevant in AI-driven environments.	
Ethical and Cultural Issues	Participants raised concerns about privacy, algorithmic bias, and the importance of human oversight.	“AI decisions must always be checked by humans; otherwise, it may create risks we cannot control.”

In table 4, we represent the themes that the employees believe regarding the adoption of AI under Industry 5.0 from the interview data. The three key themes revolved around trust and acceptance of AI, trends in human adaptability and skilling, and ethical issues. According to the first theme of trust and acceptance of AI, it showed that participants were confused by AI. Some members certainly observe efficiency gains and more streamlined workloads, while others are doubtful whether the algorithms are transparent. The phrase “AI lightens the workload, it makes decisions that I sometimes don’t understand” expressed this duality. This indicates that acceptance of AI integration was fairly high, but the lack of transparency prevents a full acceptance. According to the survey results, workers find AI useful. However, they remain sceptical about its reliability and accountability. So, trust is conditional.

One of the lesson topics focused on how humans are trainable and skilled than other animals. According to the participants, digital literacy of some sort and new adaptable skills should develop to work with AI. The quote “We will work alongside AI, but it is hard to adapt without training,” explained the fear. Industries 5.0 presented collaborative work possibilities among people (with technology) but organizations must create more structured work opportunities for those who are included to bridge skill gaps. The privacy of First Nation people as well as ethical issues around algorithmic bias and human oversight are important issues. People are more worried about the decisions that AI might make without humans. One of the respondents said, "AI decisions must be always validated by humans else it may create risks which cannot control". The employees believe ethical governance is a must-have for sustainable AI and not just a good-to-have. Most people have a similar opinion that systems cannot go wrong if it is human beings overseeing them as cultures define it that way.

These factors are potentially important for a successful AI in the long run, the themes implied. While there is strong potential for AI adoption to improve internal efficiencies and foster collaboration, it may not be the same in the long run. For implementation to be a success, emphasis must be placed on a building trust, improving human adaptability and embedding strong ethical frameworks. The qualitative findings reinforced the quantitative findings and emphasized that the AI is more than just a technical novelty. It is a socio-technical change that needs balancing. This balancing must take place between the technological advantage and the human concern.

Discussion

The findings of this study revealed that the adoption of AI and ML had strong correlations with workplace efficiency, collaboration, and job satisfaction. Human–AI integration under an Industry 5.0 framework yielded tangible benefits. The results are consistent with more recent studies which suggest that human–AI collaboration can produce substantial efficiency gains. Moreover, such investment in infrastructural

capabilities can drive innovation (Brougham & Haar, 2023). The regression results indicate that AI has a significant predictive impact on employee satisfaction and adaptability. Thus, one can argue that AI is not only an organizational tool anymore but is collaborating and changing organizational processes (Nguyen et al., 2024).

This statement sounds perfect but the topic expert may need changes so let's paraphrase it "Although there is a positive impression, qualitative data reveals issues around transparency and trust, addressing wider debates in current scholarship." Earlier studies indicated that when system performance diverged from communicated levels of confidence, user trust was disrupted and adoption slowed down (Li et al., 2024). Similarly, the interviews in this study reflected worries about over-reliance on algorithms and opacity. Trust plays an important role whether the adoption of AI will produce sustainable benefits because trust is considered important in establishing an effective collaboration with AIs (Vuori et al., 2025). Another important focus was on the use of AI tools for work off the record. Similarly, early findings indicated that a large number of employees used AI apps independently and without supervision (Shrestha et al., 2023).

The information above shows a gap in governance. Organizations' policies and ethical frameworks failed to keep pace with the speed of technological growth. As previously stated by Zavolokina et al. (2024), the study's findings served to strengthen arguments for the inclusion of workers according to the governance structures, and on the ethics applicable for the Industry 5.0. The psychological impact of AI adoption has also been studied. There is a firm association between flexibility and results or usage of A.I., the figures revealed. Employees interviewed stated that upskilling and training are critical to succeeding in an AI-driven environment.

Past studies show similar phenomena. The rise of self-efficacy and risk-taking behavior by adopting AI was mediated by organizational support and continuous learning orientation (Lee and Shin, 2024). The addition of A.I. and machine learning imparts powers and changes the behaviour of humans as well as the chances of innovation and technical efficiencies. Nonetheless, it should be noted that employees' well-being also needed attention. While it increased efficiency, participants were concerned about increased surveillance and heightened stress levels. Similar findings were reported in earlier studies that high exposure levels to AI and surveillances technologies were associated with lower quality of life in workplaces (Bai et al., 2023). Based on the findings, technology humanisation must be achieved along with wellbeing and ethical safeguards in the workplace.

The growth of Skills and Inclusion are essential enablers for Industry 5.0, the report noted. Employees are frequently asking for more investments in digital literacy training. Employee involvement coupled with upskilling is a key evidence in favour of successful AI integration (Dwivedi et al., 2023). With sufficient training, the risk of greater inequality – where those enabled by technology will undermine the wage and conditions of the workers left behind – can be avoided. Consequently, the degree of sophistication of AI and ML systems and how organization is going to enable their workforce with skills, trust and ethical protection are going to determine the future of industry 5.0. The research results confirmed that the introduction of AI and ML deliveries enhanced collaboration, efficiency and satisfaction. This is

achievable only through having trust, transparency, training and ethics in place. The most recent stage of evolution is called industry 5.0.

Conclusion

According to the study, through a suitable combination and collaboration of human-technology using AI/ML, workplaces can transform to Industry 5.0. According to the findings, AI and ML can enhance efficiency and comprehension in a workplace setup. It may also increase employee satisfaction and create new collaboration and cooperation models. However, the new conveniences required a degree of trust, transparency, and organizational support. Worries over depending on algorithms and surveillance. Governance deficiency means that successful integration will require more than the improvement of the technology. Human-centered strategies are needed that are designed for wellbeing and inclusivity. The research paper explains that Industry 5.0 refers to socio-technical transformation where there is harmony between human values and technological progress to create workplaces that can adapt for sustainability.

Recommendations

Organisations are advised to adopt regulated trust-building mechanisms before leveraging the AI and ML technologies, the research says. These included transparent communication of limitations, AI prototypes that explain themselves and employee involvement in governance frameworks. Workers will have to receive continuous training and upskilling programs to prepare them for AI-aided workplaces, while also allowing for different levels to make it as inclusive as possible. Organizations must also introduce monitoring, bias-mitigation and job-loss policies to further lessen the risks involving AI. In addition, the managers send a message to treat AI as an ally rather than a replacement for human intelligence. This reduces a loss-of-humanity practice into a mixed practice which has been infused with emotional technology.

Future Directions

Exploration of Industry 5.0 must include efficiency and job satisfaction, of course, but also the long-term psychological, ethical and socially adverse effects. Longitudinal case studies can reveal whether human interaction with A.I. has evolved over time, such that employee trust and wellbeing became sustained.

Research in other industries and cultural contexts might shed light on the differences in adoption and effectiveness of governance. Future study should include the application of emotional intelligence, diversity and inclusivity in AI-human interaction. In the end, the further development of industry 5.0 into a human-centered paradigm will require Interdisciplinary research from management, psychology, ethics and computer science.

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