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Framework for Leveraging Artificial Intelligence to Enhance Entrepreneurship in Mechanical and Industrial Engineering

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Abstract

A comprehensive framework was developed to leverage Artificial Intelligence (AI) in enhancing entrepreneurial activities in mechanical and industrial engineering fields. AI, known for automating processes and enabling data-driven decisions, has transformed industries by optimizing design, analysis, and production. However, the direct impact of AI on fostering entrepreneurship has not been thoroughly investigated. This study fills that void by conducting a systematic literature review, integrating insights from peer-reviewed literature across key databases. The findings reveal that while AI has significantly improved operational efficiency, innovation, and strategic decision-making, the integration of AI with entrepreneurial activities requires further dedicated study. The proposed framework outlines how AI technologies, including generative design, machine learning, and predictive analytics, can empower engineers to drive innovation and sustainability while creating business opportunities. By aligning AI-driven strategies with entrepreneurial objectives, the organizations can harness AI's capacity to boost competitiveness to reshape traditional engineering approaches into dynamic and progressive practices.

Keywords: Artificial intelligence, business process improvements, entrepreneurial ventures, systematic review, mechanical and industrial engineering.

1. Introduction

Artificial intelligence (AI) encompasses machines performing cognitive tasks akin to humans, including learning, understanding, reasoning, and interacting. AI manifests diversely, whether as technical algorithms, integrated into production processes, or developed as end-user products [1]. The rise of AI has been as abrupt and revolutionary [2]. Only eight years after the construction of the first digital computers in the 1940s, Claude Shannon developed Theseus in 1950, marking the advent of AI. Theseus was a remote-controlled mouse capable of navigating a labyrinth and remembering its path [2] [3]. AI has made significant strides since then, with many of these pioneering developments going largely unnoticed beyond academic, governmental, and scientific communities. However, it is only in the past decade or so that AI has been actively utilized to fulfill the needs and desires of the broader public [4]. Today, AI is omnipresent in our daily lives through technologies like chatbots, virtual assistants, self-driving cars, drones, and image recognition programs [5] [6]. Machine-learning technologies have transitioned from academia to practical applications across various domains. Neural network language models acquire knowledge of word usage through analyzing patterns in natural language text, enabling functionalities like machine translation, text classification, speech recognition, writing assistance, and chatbots [6] [7].

The growth of AI has also led to significant economic and business implications. A survey conducted in 2022 revealed that the adoption of AI has more than doubled since 2017 [8]. AI patents have been increasing globally, with an average annual growth rate of 6% between 2010 and 2015. This rate surpasses the yearly growth observed for patents in other fields [2]. AI has also become prevalent in the business sector. According to a survey of businesses in the United States, more than half (56%) of business owners utilize AI for cybersecurity and fraud management. Additionally, nearly half (46%) employ AI for developing internal communications, and almost two-thirds (64%) of business owners anticipate that AI will enhance customer relationships [9]. The trend of AI adoption extends beyond North America and is a global phenomenon. A survey conducted in 2024 revealed that in nearly every region, more than two-thirds of respondents reported that their organizations are utilizing AI [10]. In

the academic sphere, the study of AI has shown a comparable pattern. Between 2010 and 2022, the total number of AI publications nearly tripled, climbing from about 88,000 in 2010 to over 240,000 in 2022. The rise from the previous year was a modest 1.1% [11]. In 2022, there were approximately 230,000 AI journal articles and about 42,000 conference submissions. Since 2015, both AI journal and conference publications have grown at similar rates. Specifically, by 2022, there were 2.6 times as many conference publications and 2.4 times as many journal publications compared to the numbers in 2015 [11].

AI facilitates quicker, more precise, and automated decision-making, empowering companies to enhance efficiency and achieve superior results. Various industries, including banking and manufacturing, are already leveraging AI to revolutionize their operations [12]. AI has also permeated into mechanical and industrial engineering. Generative design, an innovative AI-driven approach, fundamentally transforms the engineering design landscape [13]. AI models use machine learning and real-time data to detect failures early, helping engineers plan maintenance, reduce downtime, and extend asset lifespan. They achieve this by continuously analyzing equipment performance trends and promptly detecting abnormalities [13] [14]. AI in autonomous systems and robotics has transformed manufacturing, enhancing flexibility, agility, and productivity with AI-driven automation and intelligent assembly lines [5]. AI has revolutionized mechanical engineering by innovating design, analysis, and manufacturing technologies, optimizing processes to achieve greater efficiency and precision [5] [15]. The integration of AI has significantly enhanced supply chain and logistics operations, leading to overall improvements in industry performance [16]. Mechanical engineers with expertise in AI play a crucial role in developing software for interpreting sensor data across diverse sectors, ranging from power plants to consumer products [17]. AI applications automate design processes and optimize mechanical systems such as engines and gears, minimizing errors and enhancing product reliability, thereby boosting customer satisfaction [18]. Furthermore, advancements in additive manufacturing, automation, and digitalization are driving ongoing progress in the field [18]. Automated material handling and AI-driven robotic assembly lines are becoming increasingly prevalent in modern manufacturing, fostering both flexibility and productivity [5].

Industrial AI is revolutionizing production processes by automating tasks and improving efficiency, leading to substantial economic and social benefits [19]. In modern industrial engineering, AI-driven technologies are transforming supply chain strategies and optimizing production, process design, operational management, and decision-making [19] [20]. AI enables efficient resource utilization and real-time data monitoring, transforming traditional factories into smart facilities that prioritize sustainability and environmental responsibility [19]. Key AI technologies such as IoT (Internet of Things), Big Data analytics, ERP (Enterprise Resource Planning), MES (Manufacturing Execution System), and PCS (Process Control Systems) play a crucial role in developing intelligent control systems. These systems ensure quality assurance and forecast global market trends effectively. This proactive approach aligns with circular economy principles, aiming to reduce waste and optimize material efficiency across the entire supply chain [20]. AI offers significant opportunities across industries, but adoption is hindered by the "long-tail" problem. Unlike large-scale AI systems in tech, many sectors require numerous smaller, customized systems, which are costly and resource-intensive to develop, limiting widespread implementation and leaving AI's full potential untapped [21].

This study aims to create an innovative framework for evaluating the impact of AI on fostering entrepreneurial activities within the mechanical and industrial engineering sectors. The primary objective is to pinpoint key areas where AI can facilitate innovation in these fields. The proposed framework will explore how AI technologies can support innovation, improve operational efficiency, and stimulate entrepreneurial ventures in engineering domains.

2. Methodology

To perform an accurate analysis of the relation between business development and AI as a field of research, as well as to collect and link together as many relevant existing studies as possible, we performed a systematic literature review. The iterative search process of defining the query for our systematic literature review analysis began by focusing on two main classes of terms: one related to “business development” and one related to “artificial intelligence.” For searching papers, we included keywords like, “AI and business development”, “Business development with help of AI”, “Business and AI”, “Business performance with AI”, “Machine learning for AI” “Mechanical Engineering business”; “Industrial Engineering business”; “entrepreneurial activities”. The review was limited to peer-reviewed and English journal articles (peer-reviewed) published across three databases –Scopus, Web of Science and SSCI – searching for terms in the article’s title, abstract and keywords.

Fig. 1 illustrates the flowchart of the systematic literature review process conducted for this study. The review began with an initial comprehensive search using predefined search strings across three major databases: Scopus, Web of Science, and SSCI, yielding a total of 50 papers (25 from Scopus, 12 from Web of Science, and 13 from SSCI). The second phase involved identifying and eliminating duplicate studies, which reduced the collection to 37 unique papers. In the third step, abstracts were thoroughly evaluated, leading to the exclusion of 6 studies classified as working papers or non-peer-reviewed articles. This filtering process resulted in a final set of 31 peer-reviewed journal articles that satisfied the inclusion criteria and were selected for detailed analysis.

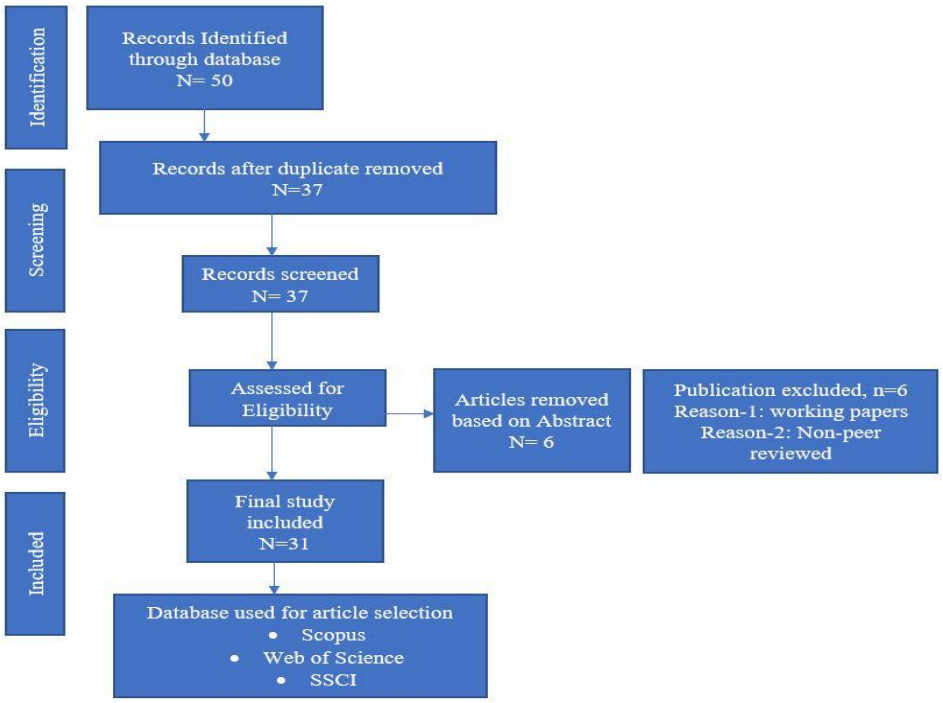


Fig 1. Systematic Literature Review Flow Chart

3. Literature Analysis

This section offers a detailed literature analysis, organized into several key themes:

Theme 1: Consumer Engagement and Experience

The literature highlights the need to balance AI efficiency with a human touch in customer interactions [22]. AI tools like chatbots and personalized marketing improve customer service with faster, more accurate responses. However, there is a risk of customer alienation if interactions feel too machine-driven. While AI enhances speed and precision, human interaction is crucial for trust, empathy, and emotional connection, especially in relationship-driven industries. Balancing automation with human warmth remains a challenge, requiring further research.

Theme 2: Competitive Advantage through AI

AI offers businesses a competitive edge by enhancing digital strategies, driving innovation, and improving decision-making [8], [23]. The literature lacks actionable frameworks to align AI with broader business strategies. While AI's potential is clear, guidelines for integrating it into competitive strategies are limited. Research shows that while AI tools like chatbots enhance agility, smaller firms benefit more from routine AI, and larger firms from innovative applications. Further research is needed to explore how businesses of different sizes can best leverage AI.

Theme 3: Knowledge Sharing and AI

AI-driven knowledge sharing enhances collaboration, streamlines workflows, and accelerates innovation. However, employee resistance, particularly in hierarchical organizations with siloed knowledge, remains a significant barrier to AI adoption [24]. Employees may resist AI due to concerns about job displacement or disruption of established power structures [6]. While AI drives business model innovation, the literature lacks practical guidance on overcoming organizational hurdles like resistance and cultural barriers. More insights are needed to help organizations foster a culture of AI adoption and address human and structural challenges.

Theme 4: Adoption Challenges and Ethical Concerns

AI adoption raises ethical concerns like data privacy, transparency, and accountability. While these issues are acknowledged, the literature often lacks specific guidance on developing regulatory frameworks and implementing responsible AI practices [25]. Ethical risks like biased algorithms and lack of transparency require businesses to ensure AI systems align with societal norms and regulations [26]. A deeper exploration of how businesses can navigate ethical challenges would strengthen the literature and offer clearer pathways for implementing responsible AI practices.

Theme 5: Machine Learning and Business Process Improvements

The extant literature challenges the idea that more complex machine learning models always outperform simpler ones [7], [5]. In scenarios with limited data, simpler models like decision trees can yield better results [5], [6].

Businesses should prioritize simplicity and adaptability in AI models, choosing ones that meet specific needs rather than pursuing unnecessary complexity.

Theme 6: Strategic Performance

AI has a proven impact on strategic performance by enhancing decision-making and optimizing processes. However, the literature lacks specific insights into which decision-making processes benefit most from AI [24]. While AI aids in forecasting, predictive analytics, and data-driven decision-making, more research is needed to identify which areas—such as supply chain management or customer segmentation—see the most improvement [27], [26]. More detailed guidance on where to focus AI efforts can help businesses achieve the best ROI from AI integration.

Each theme highlights AI's potential in business and gaps in literature. A holistic approach linking AI with entrepreneurial strategy can enhance efficiency, drive innovation, and help businesses thrive in a competitive digital landscape.

4. Discussion

The literature highlights AI's shift from a nascent technology to a vital tool, comparable to ERP systems, enhancing efficiency and competitiveness across sectors [22]. Strategic AI implementations aimed at consumer and employee engagement, as well as addressing technical challenges in product development and service delivery [22]. However, gaps remain in understanding how these applications directly influence consumer experiences, suggesting a need for further exploration. While AI integration in customer relations demonstrates potential business value by optimizing processes, challenges persist in managing AI-human interactions effectively [28] [12]. Moreover, empirical studies emphasize AI's role in driving innovation [28], productivity, and organizational transformation through knowledge sharing, business model innovation [29], and process automation [28]. Wang et al. (2022) provide insights into AI's agility in applications like chatbots [24], while Chen and Prentice (2022) establish positive correlations between AI adoption and customer satisfaction across marketing domains [25].

The literature overlooks AI's direct impact on entrepreneurial outcomes in mechanical and industrial engineering, focusing mainly on operational improvements [23], and market entry strategies—which are under-researched in these sectors [27]. To address these gaps, this study proposes a novel framework integrating AI and entrepreneurship strategies tailored to engineering firms. The framework synthesizes insights across AI's contributions to innovation, operational efficiency, strategic decision-making, and customer engagement [26] within the context of mechanical and industrial engineering. By aligning AI strategies with business objectives—across sustainability, financial, operational, and market dimensions [29], the framework consolidates existing knowledge and provides a roadmap for future research, aiming to unlock AI's full potential in driving innovation and competitiveness [23] in these critical sectors. Chalmers and colleagues (2020) also recommended that the integration of AI into organizational frameworks is increasingly essential [30]. Our proposed framework is inspired by Chalmers' model for its focus on using AI in entrepreneurship, including strategies, decision-making, process improvements, and innovation through big data, automation, and augmentation [30]. Its flexibility makes it ideal for studying AI's role in entrepreneurship, connecting theory with practice in mechanical and industrial engineering.

AI is now a standard tool, like ERP systems, boosting efficiency by automating tasks and supporting decision-making. It improves operational efficiency and optimizes workflows, especially in complex engineering industries [26]. Moreover, AI's ability to process large datasets enables automated decision-making, providing valuable insights that are pivotal for informed strategic decisions. Integrating AI with entrepreneurial strategies improves operations, sales, marketing, customer engagement, and market performance, boosting economic value [24]. Strategically implementing AI is proposed to catalyze organizational performance, especially in fields like industrial and mechanical engineering [26]. With capabilities in automation, decision-making, and design, AI enhances performance and accelerates design cycles in engineering, driving innovation and operational efficiency. Hence, a novel framework is proposed for AI-enabled entrepreneurial processes in mechanical and industrial engineering industries.

Fig. 2 shows a framework for strategic AI development, combining AI and entrepreneurial strategies to enhance performance in mechanical and industrial engineering. Key elements include AI tools (machine learning, data analytics, and automation) for efficiency and informed decision-making and entrepreneurial strategies (opportunity recognition, risk management) for innovation. This integration highlights a growing trend where AI can support and enhance entrepreneurial strategies, allowing businesses to streamline operations, foster innovation, and gain competitive advantages [31].

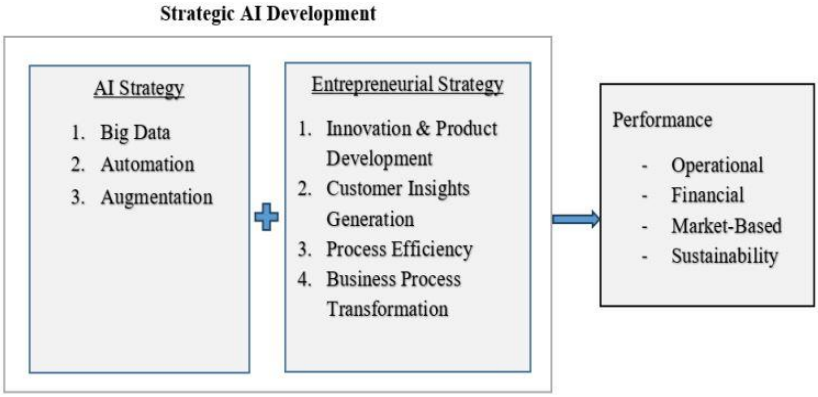


Fig 2. AI-enabled entrepreneurial process in mechanical and industrial engineering businesses

AI-driven entrepreneurship sparks innovation across industries. In manufacturing, AI sensors predict machine failures and schedule maintenance to reduce downtime. In logistics, AI optimizes routes for faster deliveries, lower costs, and reduced emissions. AI also tracks energy use in industrial settings to improve efficiency and support sustainability. It enables custom vehicle designs, boosts manufacturing efficiency, and predicts trends like Industry 4.0 and the demand for green technologies, helping businesses adapt and innovate. Strategically integrating AI provides businesses with a unique opportunity to unlock a diverse range of benefits. These benefits include enhanced customer experiences, smarter decision-making, improved product development cycles, and the ability to stay ahead of competitors [32]. Eventually, the integration of AI can lead to significant improvements in organizational performance, making businesses more agile and efficient in a rapidly advancing digital economy.

5. Conclusion

The study aimed at the current state of AI research and forged a way forward for its wide scale adoption by industrial and mechanical engineering firms. Our framework offers a comprehensive perspective on AI's potential impact on organizations, emphasizing its role as a catalyst for efficiency, innovation, and strategic alignment. By integrating AI with entrepreneurial strategies, engineering firms can leverage their capabilities to achieve competitive advantages through improved operational efficiencies and enhanced market performance.

Nevertheless, the high cost of customized solutions and limited access for smaller enterprises requires further research into democratizing AI to ensure equitable access and broader adoption by organizations. Also, understanding how AI can integrate into organizational strategies, as it requires adaptation, is subject to further study. This would ensure enhanced AI benefits across diverse organizational functions that will eventually foster a more inclusive and impactful AI-driven ecosystem, driving sustainable growth and innovation across industries.

6. References

[1] S.Mishra and A.R.Tripathi, "AI Business Model: An Integrative Business Approach", *Journal of Innovation and Entrepreneurship*, Vol. 10, No. 18, 2021.

[2] G.M. Andrzej, P.Katarzyna, and L.M.W. Clark, "A History of Artificial Intelligence", *ScienceDirect*, Vol. 42, No. 3, pp. 221-229, 2024.

[3] A. Ali, S. Naeem, S. Anam, and M. M. Ahmed, "Shannon Entropy in Artificial Intelligence and Its Applications Based on Information Theory", *Journal of Applied and Emerging Sciences*, Vol. 13, No. 01, 2023.

[4] B.Williamson and R.Eynon, "Historical Threads, Missing Links, and Future Directions in AI in Education", *Learning, Media And Technology*, Vol. 45, No. 3, pp. 223–235, 2020.

[5] S. Mondal and S.S. Goswami, "Rise of Intelligent Machines: Influence of Artificial Intelligence on Mechanical Engineering Innovation", *Spectrum of Engineering and Management Sciences*, Vol. 2, No.1, pp. 46-55, 2024.

[6] X. Tian, R. Pavur, H. Han, and L. Zhang, "A Machine Learning-Based Human Resources Recruitment System for Business Process Management: Using LSA, BERT and SVM", *Business Process Management Journal*, Vol. 29, No. 1, pp. 202-222, 2022.

[7] R. Y. Choi, A. S. Coyner, J. Kalpathy-Cramer, M. F. Chiang, and J. P. Campbell, "Introduction to Machine Learning, Neural Networks, and Deep Learning", *Translational Vision Science & Technology*, Vol. 9, No. 2, pp. 1-12, 2020.

[8] C.D. Duong, "What makes for digital entrepreneurs? The role of AI-related drivers for nascent digital start-up activities", *European Journal of Innovation Management*, 2024.

[9] C. Ledro, A. Nosella, and A. Vinelli, "Artificial Intelligence in Customer Relationship Management: Literature Review and Future Research Directions", *Journal of Business & Industrial Marketing,* Vol.37, No.13, pp. 48-63, 2022.
[10] M. Savastano, I. Biclesanu, S. Anagnoste, F. Laviola and N. Cucari, "Enterprise chatbots in managers' perception: a stra framework to implement successful chatbot applications for business decisions", *Management Decision*, No. 0025-1747, 2024.
[11] G. Wagner, R. Lukyanenko, and G. Pare, "Artificial intelligence and the conduct of literature reviews", *Journal of Information Technology*, Vol. 37, No. 2, pp. 209–226, 2022.
[12] F. Olan, E. Arakpogun, J. Suklan, F. Nakpodia, N. Damij, and U. Jayawickrama, "Artificial intelligence and knowledge sharing: Contributing factors to organizational performance", *J. of Bus. Research,* Vol. 145, pp. 605-615, 2022.
[13] A.R. Patel, K.K. Ramaiya, C.V. Bhatia, H.N. Shah, and S.N. Bhavsar, "Artificial Intelligence: Prospect in Mechanical Engineering Field—A Review", Data Science and Intelligent Applications, *Springer*, pp. 267–282, 2020.
[14] S.S. Kumara, D.A. Kumara, S.Souravb, and G. S. Shubhraa, "Assessing the role of Sustainable Development in mitigating the issue of Global Warming", *J. of Process Management and New Technologies,* Vol. 11, No. 1-2, pp. 1-21, 2023.
[15] A.K. Adeleke, D.J.P. Montero, K.A. Olu-lawal, and O. K. Olajiga, "Process Development in Mechanical Engineering: Innovations, Challenges, and Opportunities", *Eng. Sc.& Tech. J.,* Vol. 5, No.3, pp. 901-912, 2024.
[16] D. Mahat, K.Niranjan, C.S. K.V.R. Naidu, S.B.G.T. Babu, M.S. Kumar, and L., Natrayan, "AI-Driven Optimization of Supply Chain and Logistics in Mechanical Engineering," in *10th IEEE Uttar Pradesh Section International Conference on Electrical, Electronics and Computer Engineering (UPCON)*, Uttar Pradesh, pp. 1611-1616, 2023.
[17] F.Artkin, "Applications of Artificial Intelligence in Mechanical Engineering," *European Journal of Science and Technology*, No. 45, pp. 159-163, 2022.
[18] J. Jenis, J.Ondriga, S. Hrcek, F. Brumercik, M. Cuchor, and E. Sadovsky, "Engineering Applications of Artificial Intelligence in Mechanical Design and Optimization", *Machines* , No. 11, pp. 577, 2023.
[19] T. Yang, X. Yi, S. Lu, K. H. Johansson, and T. Chai, "Intelligent Manufacturing for the Process Industry Driven by Industrial Artificial Intelligence", *Engineering*, Vol. 7, pp. 1224–1230, 2021.
[20] Z. Cheng, "Intelligent Supply Chain Management: An Industrial Engineering Approach", *Proc. of the 9th International Conference on Social Sciences and Economic Development (ICSSED 2024)*, pp. 69-76, 2024.
[21] "Andrew Ng," Nov 2022. [Online]. Available: https://diginomica.com/ais-long-tail-preventing-mature-adoption-says-andrew-ng.
[22] F. Kitsios and M. Kamariotou, "Artificial Intelligence and Business Strategy towards Digital Transformation: A Research Agenda," *Sustainability*, Vol.13, No. 4, 2021.
[23] A. Abdulaziz, N. ,.-K. Khalifa and M. H. Abdel, "AI-Powered Innovation in Digital Transformation: Key Pillars and Industry Impact," *Sustainability*, Vol. 16, No. 5, p. 1790, 2024.
[24] A. George, P. Omari, K. K. Desmond, C. A. George and A. George, "Conceptual Framework—Artificial Intelligence and Better Entrepreneurial Decision-Making: The Influence of Customer Preference, Industry Benchmark, and Employee Involvement in an Emerging Market," *Risk and Financial Management,* Vol. 14, No. 12, pp. 604, 2021.
[25] Y. Chen, M. I. Biswas and M. S. Talukder, "The role of artificial intelligence in effective business operation during COVID-19," *International Journal of Emerging Markets,* Vol. 18, pp. 6368-6387, 2023.
[26] E. Mahboob, O. A. Samuel, L. M. L. Jose and A. P. G. Jose, "A comprehensive literature review of the applications of AI techniques through the lifecycle of industrial equipment," Discover Artificial Intelligence, Vol. 3, No. 43, 2023.
[27] C. Dominic, G. ,. Niall and C. Sara, "Artificial Intelligence and Entrepreneurship: Implications for Venture Creation in the Fourth Industrial Revolution," *Sage*, Vol. 45, No. 5, pp. 955-1303, 2021.
[28] A. Zebec and M. I. Štemberger, "Creating AI business value through BPM capabilities," *Business Process Management Journal*, Vol.30, No.8, pp. 1-26, 2024.
[29] N. Upadhyay, S. Upadhyay, M. M. Al-Debei, A. M. Baabdullah and Y. K. Dwivedi, "The influence of digital entrepreneurship and entrepreneurial orientation on intention of family businesses to adopt artificial intelligence: examining the mediating role of business innovativeness," *Int. J. of Entre. Behavior & Res.*, Vol.29, No.1, pp. 80-115, 2023.
[30] D. Chalmers, N. G. MacKenzie, and S. Carter, "Artificial intelligence and entrepreneurship: Implications for Venture creation in the Fourth Industrial Revolution," *Entrepreneurship Theory and Practice*, Vol. 45, No. 5, pp. 1028–1053, 2020.
[31] G. Guglielmo and M. M. Pellegrini, "Artificial intelligence as an enabler for entrepreneurs: a systematic literature review and an agenda for future research," *Int. J. of Entre.Behaviour & Research*, Vol. 29, No. 4, pp. 816–837, 2022.
[32] S. Edilia and N. D. Larasati, "Innovative approaches in business development strategies through artificial intelligence technology", *IAIC Transactions on Sustainable Digital Innovation (ITSDI)*, Vol. 5, No.1, pp. 84-90, 2023.