Digital Leadership in the Era of Industry 4.0: A Comprehensive Literature Review

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Abstract. The advent of Industry 4.0 has revolutionized the landscape of leadership, emphasizing the critical role of digital leadership in navigating technological advancements and organizational transformations. This comprehensive literature review explores the evolving concept of digital leadership within the context of Industry 4.0, aiming to synthesize current research findings, identify emerging trends, and highlight best practices. Through a systematic analysis of peer-reviewed articles, books, and conference papers from the last decade, this study examines the key attributes, strategies, and impacts of digital leadership on organizational performance and innovation. The review reveals that effective digital leaders exhibit a combination of technological proficiency, visionary thinking, and adaptive management skills. Furthermore, it underscores the importance of fostering a digital culture, promoting continuous learning, and leveraging data-driven decision-making to drive organizational success. By providing a holistic understanding of digital leadership, this study offers valuable insights for academics and practitioners seeking to enhance leadership effectiveness in the digital age. The findings underscore the necessity for organizations to invest in leadership development programs that align with the demands of Industry 4.0, ensuring leaders are equipped to lead in a rapidly changing technological environment.

Keywords : Digital Leadership, Era of Industry 4.0, Literature Review

INTRODUCTION

The Industry 4.0 era, characterized by the integration of advanced technologies such as artificial intelligence, machine learning, and data analysis, has had a significant impact on organizations in various sectors. This revolution has led to the evolution of business models, digital transformation, and the need for innovative practices in organizations (Mustapha et al., 2020) Executive managerial decisions have become critical in navigating technological advances and data management requirements of Industry 4.0, emphasizing the importance of quality management, risk management , and regulatory compliance (Kora, Holta, 2022) The shift towards Industry 4.0 is not only about technology but also about changes in the business environment, increased flexibility, and increased production efficiency through digital transformation (Günter Jeschke, 2023) . Organizations are encouraged to embrace Industry 4.0 to promote innovation strategies, respond quickly to market changes, and leverage the benefits of predictive analytics and machine learning for operational excellence and competitiveness (October et al., 2022) Additionally, the role of artificial intelligence in Industry 4.0 is critical , driving increased efficiency, productivity, and the creation of new revenue streams and

business models, ultimately shaping the global economy and transforming industries around the world (Parimi, Vijaya, Raju., T., 2023) .

Digital leadership in the context of Industry 4.0 refers to a type of leadership that utilizes digital technology to drive organizational transformation and development, emphasizing the importance of modern leadership theory (Hargitai & Bencsik, 2023) (Topcuoglu et al., 2023) . It plays an important role in cultivating a learning organizational culture that is essential for digital transformation, influencing factors such as leadership behavior, training, digital readiness, and trust (Elaine et al., 2023) Digital leaders play an important role in enhancing employee creativity through job crafting and person-organization fit, which ultimately contributes to a company's success in the digital era (Zhu et al., 2022) As organizations transition to virtual environments, digital leadership becomes increasingly important to adapt to the demands of the digital era, requiring leaders with advanced digital competencies and approaches visionary to navigate the complexity of virtual organizational structures (Hasan Tutar, 2022)

Digital leadership is especially important in the Industry 4.0 era, where organizations face significant challenges due to technological advances and societal changes (Behie et al., 2023) (Syahputra et al., 2023) . Rapid digitalization across sectors requires leaders to adopt new roles and skills to effectively navigate the complexities of the fourth industrial revolution (Puja Khatri, 2023) . The study emphasizes the importance of digital leadership strategies in Society 4.0, highlighting key approaches such as systems thinking, contextual intelligence, and metacognitive strategies (Budiarti, 2022) . Furthermore, the evolution of educational philosophies in the modern era underscores the need for Christian education to adapt to the changing landscape driven by Industry 4.0, ensuring that values remain rooted in basic principles (Swastoko, 2022) . organizations to thrive in the dynamic and disruptive Industry 4.0 environment.

Based on the background above, the problem formulation will be: What are the leadership models and characteristics needed to face the 4.0 era? What are the opportunities and challenges that will be faced in digital era leadership? To answer this question, the author is interested in lifting the title above.

RESEARCH METHODS

This research uses a descriptive-qualitative approach and literature study. The author examines literature such as journals, books and scientific articles as the main subject of this research. The author chose a qualitative research method because this type of research is

accountable and reliable. Data triangulation is used to evaluate data validity by comparing various data sources. To obtain data, journals, e-books and theses are searched via the internet. To carry out searches using scientific works published on Google Scholar, Elsevier, and Scopus, keywords such as Madrasah Strategy, Era of Globalization, and Religious Moderation are used. Journals that are relevant to these keywords are selected. The results show that researchers have selected fifty journals to analyze, summarize, and classify. to develop new ideas and thoughts that remain relevant to the topic of conversation.

Next, the data was analyzed descriptively and interpreted by considering the development of religious moderation in madrasas. (Solatun, 2008) Research qualitative can interpreted US method To use explore as well as understand meaning by groups person or a number individual from community/social or related humanity . (New & Indonesian, nd) Method looks research deductive applied by researchers Which involved active in research This with focused on meaning individual, as well as translate complexity problem Which There is. (Creswell & Creswell, 2018) Data is classified according to existing problems and then analyzed using deductive, inductive and comparative methods. (Zubar, 2002) , which aims to make data easy to read, understand and interpret. The purpose of interpretation is to obtain meaning and significance from the data . (Patton, 2000)

RESULTS AND DISCUSSION

Definition and Concept of Digital Leadership

Digital leadership is an important concept that has emerged in response to the rapid digitalization of various sectors, especially with the emergence of Industry 4.0 (Topcuoglu et al., 2023) (Elaine et al., 2023) . It involves leaders experienced in digital technology, driving the digital transformation of both employees and organizations while drawing from modern leadership theory (Hensellek, 2020) In the context of the Fourth Industrial Revolution, digital transformation requires a shift in management models to ensure competitiveness and survival in the market, highlighting the importance of leadership in this process (Hasan Tutar, 2022) . Digital leadership requires individuals to have not only technical skills but also a digital mindset to navigate the opportunities and challenges presented by digitalization, ultimately contributing to successful digital transformation in both the economy and society (Oktaysoy et al., 2022) . Organizations are increasingly realizing the importance of digital leadership in virtual environments, where leaders with advanced digital competencies play a critical role in driving innovation, adapting to remote work structures, and cultivating a culture of continuous learning aligned with digital standards.

Key elements of digital leadership.

Digital leadership includes several key elements essential for success in the digital era. These elements include having a visionary leadership approach, cultivating a digital era learning culture, promoting excellence in professional practice, encouraging systemic improvement, and instilling digital citizenship (Timan & Imron, 2022) . In addition, having a digital mindset to understand the impact of digital technology, getting information about digital transformation, and integrating modern leadership theories are important components of digital leadership (Hensellek, 2020) (Brigitte, 2022) (Topcuoglu et al., 2023) . Additionally, managing a diverse workforce with cultural intelligence (CQ) is critical for effective leadership in a globalized and hypercompetitive world, especially in real-time cross-cultural interactions (Rüth & Netzer, 2020) . By combining these elements, digital leaders can navigate the complexities of the digital landscape, drive organizational growth, and ensure success in the rapidly evolving digital era.

The Role of Technology in Digital Leadership

Technology plays a critical role in digital leadership, influencing various aspects of organizational success. Research shows that digital leadership has a positive impact on employee performance through factors such as digital competence and information technology (Hidayat et al., 2023) . Additionally, technology readiness, training, and trust are important components that interact with leadership style to enhance digital transformation in organizations (Hargitai & Bencsik, 2023) . In addition, digital leadership is seen as a key element in adapting to digital transformation, contributing to system efficiency, productivity and successful business strategies (Türk, 2023) . Additionally, digital technology, when combined with strategic leadership, can significantly impact digital business operations, increasing competitiveness, productivity and growth in sectors such as banking (Topcuoglu et al., 2023) . Overall, technology is the driving force behind effective digital leadership, shaping organizational culture, performance and competitiveness in a rapidly evolving digital era.

Key technologies that support digital leadership

Key technologies supporting digital leadership include mobile technology, cloud computing, big data, social media, Internet of Things (IoT), intelligent automation, artificial intelligence, and machine learning. These technologies play a critical role in enabling business innovation, increasing customer centricity, and driving digital transformation in organizations (Hargitai & Bencsik, 2023) Strategic leadership in digital requires a clear vision, a culture of

innovation, and constant adaptation to technological advances to remain competitive and drive growth and profitability. Additionally, digital leaders integrate advanced technologies such as AI and machine learning to improve usability of data, digitizing products and services, and building technology partnerships for a successful digital transition (N. Abidi, R. Yanamandra, HKG Nair, 2023) . Overall, these technologies empower leaders to navigate the complexities of digitalization and drive organizational success in the digital era.

The influence of technology on leadership strategy and decision making

Technology plays an important role in shaping leadership strategies and decision-making processes in various sectors. Studies emphasize that technology improves communication, transparency, and decision making in organizations, leading to increased efficiency and responsiveness to stakeholders (Bukhari, 2023) Additionally, the adoption of modern technologies such as artificial intelligence, big data, and cloud computing affects organizational effectiveness, teamwork, and strategic decision making, highlighting the importance of embracing these innovations to improve performance and competitiveness (Yaroslavovych & Nataliya, 2023) . Furthermore, a study of a large telecommunications company in Kenya underscores the significant impact of technological innovation on competitive advantage, with strategic leadership playing an important moderating role in strengthening this relationship, emphasizing the vital role of leaders as drivers of innovation for sustainable competitive advantage (Anju, 2022)

Characteristics of Digital Leaders in the Industrial Era 4.0

Digital leaders in the Industry 4.0 era are expected to have unique skills and leadership styles to navigate the challenges and opportunities brought by digital transformation. These leaders must demonstrate characteristics such as effective communication, knowledge and understanding, well-defined standards and methods, coaching abilities, openness, transparency, trust, employee orientation, and a culture that embraces learning from mistakes (Puja Khatri, 2023) (Z., H., L., 2022) (Puhovichová & Jankelov, 2021) . They are required to act quickly and flexibly within a network structure while managing the digital transformation of their organizations (Klein, 2020) . Additionally, digital leaders must have cognitive, business, interpersonal, and strategic skills to thrive in the Industry 4.0 landscape (Durmaz, 2022) . A transformational leadership style that promotes adaptation to environmental changes and increases the long-term success of employees and organizations is considered important in this era.

Competencies and skills required to become a digital leader

Becoming a successful digital leader requires a unique set of competencies and skills that go beyond traditional leadership qualities. Research emphasizes that digital transformation experts must possess collaboration, strategic thinking, leadership, customer orientation, and communication skills, along with certain personality traits such as proactivity and creativity (Nippa & Knappstein, 2023) . In the era of digital transformation, organizations demand leaders with a deep understanding of the impact of digital technology on business, even if they are not technical experts themselves (Frank, J., 2022) . In addition, digital leadership requires a new form of leadership that integrates digital skills and a digital mindset to navigate the challenges and opportunities of the digital era (Güler & Tutar, 2022) (Brigitte, 2022) . Therefore, to excel as a digital leader, individuals must combine technical knowledge with visionary leadership, adaptability, and a keen awareness of the digital landscape.

Effective leadership styles in digital contexts

An effective leadership style in a digital context is critical to organizational success. Research shows that transformational leadership is more effective in directing employees towards goals compared to transactional leadership, which can have a negative impact on virtual teams (Wijaya et al., 2023) . Health-oriented leadership has positive effects on mental fatigue and work-related attitudes, but its effectiveness may vary between on-site and digital work environments, emphasizing the importance of regular face-to-face contact (Klebe, 2023) . Strategic leadership plays a critical role in digital business success, with a clear vision, a culture of innovation, and adaptation to technological change being key factors for competitiveness and growth (N. Abidi, R. Yanamandra, HKG Nair, 2023) . Additionally, leadership style has been shown to significantly influence employee performance in the digital era, highlighting the continued relevance of effective leadership in improving performance at all levels (Mulatsih, 2022) . In the public sector, digital leadership is essential to utilize ICT effectively, increasing transparency, accountability and public participation in decision-making processes, ultimately improving the delivery and results of public services (Riki Nuryadin, A Sobandi, 2023) .

Challenges and Opportunities in Digital Leadership

Digital leadership presents challenges and opportunities in the public and private sectors. Challenges include the need for leaders to develop a digital mindset to understand the implications of digitalization (Wijaya et al., 2023) (Hensellek, 2020) is especially highlighted

during crises such as the Covid-19 pandemic, where social skills and self-competence become important for effective leadership (El Akid, 2023) . The shift to virtual offices due to the pandemic has emphasized the importance of e-leadership, requiring competence in managing emotions and building e-trust in virtual environments (Liu, S. & Rajendran, 2023) . Additionally, increasing reliance on technology-based interactions poses challenges to developing effective leadership, emphasizing the importance of face-to-face interactions for building strong interpersonal relationships within organizations (Lee, 2023) . Addressing these challenges can lead to increased transparency, accountability and public participation, ultimately improving the quality and accessibility of public services

Challenges faced by digital leaders (examples: cybersecurity, technology adaptation).

Digital leaders face a variety of challenges, including cybersecurity threats and the need for rapid technological adaptation. The Covid-19 pandemic has accelerated the shift towards remote work, highlighting the importance of digital leadership skills such as empathy, conflict management and openness to innovation (Emily, H., 2023) . Executives navigating digitalization must have entrepreneurial thinking, IT skills, and the ability to motivate others while finding a balance between old and new practices (Ellen Weber, Eva-Helen Krehl, 2019) . In the evolving cyber-physical systems landscape, leaders must address rapid product cycles driven by changing customer needs through agile production and development cycles, requiring new leadership approaches and organizational cultures (Frederik & Julia, 2021) . Overall, digital leaders must navigate complex digital environments, stay ahead of cybersecurity threats, and continuously adapt to technological advances to ensure organizational success.

Opportunities offered by digital leadership in improving organizational performance.

Digital leadership presents various opportunities to improve organizational performance. Studies have shown that digital leadership positively influences organizational culture, employee innovation behavior, and ultimately organizational innovation performance (Zhong et al., 2023) (Djati et al., 2023) . In addition, digital leadership plays an important role in increasing digital competence, organizational commitment, and overall performance in organizations (Gunawan et al., 2023) (Topcuoglu et al., 2023) . The ability of digital leadership to drive digital transformation and innovation is critical in today's rapidly changing business environment, where organizations must adapt to technological advances to remain competitive and ensure their survival (Diana, H., 2023) . By leveraging digital leadership strategies,

businesses can effectively navigate digital disruption, increase productivity, and reduce negative organizational behaviors such as social strikes, ultimately leading to improved job performance and organizational success.

Identify key trends in digital leadership.

Key trends in digital leadership include the need for leaders to have specific skills such as being visionary, customer-centric, and adaptable to change (Tze, Yin, Khaw., Ai, Ping, Teoh., Siti, Nabiha, Abdul, Khalid. , Sukumar, 2022) . Additionally, a shift towards more flexible organizational structures, reduced hierarchies, and increased collaboration in business is becoming prominent (Tagscherer & Carbon, 2023) . Digital leadership is critical to improving sustainable performance in organizations, with elements such as leadership style, antecedents of good leadership, and effective leadership outcomes being important considerations (Mansi Dudeja, 2023) . Additionally, the impact of digital leadership extends to improving teacher performance and student competency in the 21st century, emphasizing components such as visionary leadership, a digital era learning culture, and excellence in professional practice (Timan & Imron, 2022) . As leadership scholarship transitions to the digital era, there is a growing need to understand leadership in informal contexts, utilize technologies such as Big Data, and adapt methodological approaches to studying leadership in the digital era (Banks et al., 2022) .

CONCLUSION

The development of the times means that all elements in life also change, including leadership models. In the current digital era, such as era 4.0, where almost all lines of life use technology, leadership in educational institutions also has an influence. For this reason, the characteristics of a leader in the current digital era are certainly a matter of concern. Ability to use technology aimed at facilitating leadership. Opportunities and challenges will definitely be found as technology advances and moves quickly. To deal with this, a leader must be able to overcome cyber problems, including hackers. So that information and data are safe and protected

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