Industry 4.0 and Fayol's 14 Principles of Functional Management: Relevances, Emerging Practices and Consequences

Abstract:

Aim: This study aims to examine and evaluate the relevance and importance of Henri Fayol's principles of management and its emerging practices in the context of Industry 4.0.

Approach: The study employs a literature review approach to analyze and synthesize existing research and literature related to Fayol's principles of management and their applicability in the age of Industry 4.0.

Findings: The analysis shows that several of Fayol's principles, including division of labor, authority and responsibility, discipline, order, equity, and stability of tenure of personnel, remain remarkably relevant in the digital age. But, some principles, such as unity of command and unity of direction, may need to be adapted in decentralized decision-making and cross-functional collaboration. The study also identifies new management practices and methodologies, such as agile methodologies, design thinking, and data-driven decision-making, that are emerging to meet the demands of Industry 4.0. By adapting and applying Fayol's principles in new and innovative ways, businesses can leverage the opportunities of Industry 4.0 while ensuring a positive work environment and employee satisfaction.

Originality/Value: This study provides valuable insights for businesses and management practitioners on the continued relevance and applicability of Fayol's principles of management in the age of Industry 4.0. The study also highlights the need for businesses to invest in employee learning and development, utilize data and analytics, and explore new tactics and practices better suited to the digital age.

Keywords: Henri Fayol, Principles of Management, Industry 4.0, digital transformation, management practices

1. Introduction:

Industry 4.0, also known as digital transformation, is revolutionizing how businesses operate, compete, and interact in the global market (Schwab, 2016). The intersection of Henri Fayol's 14 Principles of Functional Management and Industry 4.0 signifies a significant fusion of traditional management theory and state-of-the-art technology (Smith, 2020). The fourth Industrial Revolution, known as Industry 4.0, is important due to the paradigm shift involving data-driven decision-making, automation, and advanced digital technologies that define the stages of the manufacturing system (Jones & Brown, 2019). The operational landscape for enterprises is being transformed by this revolution, bringing with it both incredible prospects and daunting challenges. Organizational management still relies on Fayol's concepts, which he developed more than a century ago; they provide sound advice on leading, coordinating, and regulating a group (Fayol, 1916). Their capacity to offer a thorough guide for navigating the complex dynamics of companies ensures their continued relevance, even in the face of technological innovations [112,113,114]. Regarding managerial decision-making and activity coordination, fundamental organizational principles such as the scalar chain, division of labor, and unity of command continue to play a significant role. Traditional management principles face challenges in keeping up with the demands of Industry 4.0 and the rapid growth of technology (Johnson et al., 2018). The dynamic nature of Industry 4.0 necessitates flexibility, agility, and innovation, challenging entrenched hierarchical management paradigms. This study investigates the relationship between Industry 4.0 and Fayol's 14 Principles of Functional Management in terms of its relevance, emerging practices, and consequences in a contemporary business environment. The study shapes the effect of convergence on organizational direction and engagement in the digital age. In the realm of Industry 4.0, Fayol's concepts gain increased significance as firms grapple with difficulties in digital transformation. Concepts like unity of command and division of tasks are re-explained in the context of decentralized decision-making and swift approaches, enabling dynamic collaboration among cross-functional teams to address market needs and technological changes. Likewise, equity and stability gain significance as firms attempt to establish inclusive and resilient cultures amidst rapid change. Emerging practices under the purview of Industry 4.0 accentuate the evolution of management systems in response to technological advancements. Approaches like deploying smart manufacturing systems and IoT-enabled devices indicate proactive efforts by enterprises to integrate digital technologies for enhanced efficiency and competitiveness. However, these solutions require a shift in organizational thinking away from traditional hierarchical structures towards more flexible frameworks conducive to continuous learning and innovation. Thus, the implications of Industry 4.0 and Fayol's concepts extend beyond organizational boundaries, reaching broader socio-economic implications. Workforce dynamics shift as mechanization and AI-driven equipment reshape job responsibilities, necessitating ongoing retraining and upskilling activities to prepare people for the digital age. Additionally, the societal impact of Industry 4.0 underscores the need for ethical considerations and responsible

innovation to ensure that technological advancements benefit society. The relationship between Industry 4.0 and Fayol's ideas offers a broad field for inquiry, providing insights into the new terrain of organizational management in the digital age. Through the development of techniques and effects, this study provides significant support for organizations grappling with the challenges of Industry 4.0 by developing techniques and effects. Embracing Fayol's principles while establishing digital practices encourages organizations to adopt a comprehensive approach to management, fostering agility, creativity, and environmental progress in the digital era.

Literature Review:

Henri Fayol's 14 Principles of Management have been a cornerstone of management theory for over a century (Fayol, 1916). These principles were based on Fayol's personal experience as a manager and his observations of successful managers. The 14 Principles have been used as a guide for managers for generations and have helped shape how organizations are run.

The rise of Industry 4.0, characterized by the integration of advanced technologies such as artificial intelligence, the Internet of Things, and cloud computing, has raised questions about the continued relevance of the 14 Principles of Management. Some argue that integrating new technologies has led to significant changes in how organizations operate and that the 14 Principles of Management may no longer be applicable in the age of Industry 4.0 (Shahin & Sharif, 2020). Although , others argue that the 14 Principles of Management remain relevant in the age of Industry 4.0 but that they may need to be adapted to account for the changes brought about by new technologies (Gupta, 2020).

The first principle of management is the division of work, which states that work should be divided among individuals and groups to ensure each person has a specific task (Fayol, 1916). This principle is still relevant in the age of Industry 4.0, as the integration of new technologies has led to the creation of new jobs and the automation of some tasks (Shahin & Sharif, 2020). The division of work is essential in ensuring that employees clearly understand their responsibilities and can work together effectively.

The second principle of management is authority, which states that managers must have the authority to give orders and the power to enforce obedience (Fayol, 1916). This principle remains relevant in the age of Industry 4.0, as managers must still have the authority to make decisions and ensure that employees are following established protocols. Although, integrating new technologies has led to new forms of authority, such as algorithms and automated decision-making systems (Gupta, 2020). It is essential for managers to understand these new forms of authority and to adapt their management style accordingly.

The third principle of management is discipline, which states that employees must obey and respect the rules that govern the organization (Fayol, 1916). This principle is still relevant in the age of Industry 4.0, as rules and regulations are essential in ensuring that organizations operate efficiently

and effectively (Shahin & Sharif, 2020). While, integrating new technologies has led to new forms of discipline, such as monitoring software and automated performance evaluations (Gupta, 2020). Managers need to ensure that these new forms of discipline are used ethically and fairly.

The fourth principle of management, which is the unity of command, may need to be adapted in the age of Industry 4.0, as the use of matrix organizational structures may result in employees having multiple bosses. Managers need to ensure that the lines of communication and authority are clear to avoid confusion and conflicts (Wijngaard, 2019).

The fifth principle of management, the unity of direction, remains relevant in the age of Industry 4.0, as a clear and unified direction is essential in ensuring that organizations operate efficiently and effectively. Though, integrating new technologies has led to the development of new tools and strategies for achieving organizational goals. It is essential for managers to stay up to date with these new tools and strategies and to adapt their management style accordingly (Nambiar & Devi, 2021).

The sixth principle of management, which is the subordination of individual interests to the general interest, is still relevant in the age of Industry 4.0, as the goal of any organization is to achieve its objectives and fulfill its mission. While, integrating new technologies has led to the development of new individual interests, such as work-life balance and flexible work arrangements. Managers must recognize and accommodate these new forms of individual interests while ensuring they do not conflict with the organization's interests (Kim & Lee, 2020).

The seventh principle of management, remuneration, is still relevant in the age of Industry 4.0, as fair and competitive compensation is essential in attracting and retaining top talent. Though, integrating new technologies has led to new forms of compensation, such as equity-based compensation and performance-based bonuses. Managers need to ensure that these new forms of compensation are aligned with the organization's goals and are used fairly and transparently (García-Sánchez & Rivas, 2019).

The eighth principle of management, centralization, may need to be adapted in the age of Industry 4.0, as the integration of new technologies has led to the development of new forms of decision-making, such as data-driven and distributed decision-making. Managers need to understand and utilize these new forms of decision-making while ensuring that they remain aligned with the goals and objectives of the organization (Sharma & Chhabra, 2020).

The ninth principle of management, the scalar chain, remains relevant in the age of Industry 4.0, as a transparent chain of command is essential in ensuring that communication and decision-making are efficient and effective. Though, integrating new technologies has led to new forms of communication and collaboration, such as instant messaging and online project management tools. Managers need to understand and utilize these new forms of communication and collaboration while ensuring they do not disrupt the established chain of command (Wang & Huang, 2020).

The tenth principle of management, order, remains relevant in the age of Industry 4.0, as a clean, safe, and efficient workplace is essential in promoting productivity and employee well-being. Even though, integrating new technologies has led to new workplace hazards and challenges, such as cyber threats and information overload. Managers must address these new hazards and challenges while maintaining a clean, safe, and efficient workplace (Bhattacharya & Mukhopadhyay, 2020).

The concept of equity in the workplace has been identified as an essential principle of management, and it remains relevant in the age of Industry 4.0, as it is essential in promoting employee satisfaction and retention (Fayol, 1916). Though, integrating new technologies has led to new forms of bias and discrimination, such as algorithmic bias and online harassment. To maintain equity and fairness in the workplace, managers must address these new forms of bias and discrimination (Levy & Foulsham, 2021).

The stability of tenure principle of management is also relevant in the age of Industry 4.0. Employee retention is essential in promoting organizational stability and productivity (Fayol, 1916). Although, integrating new technologies has led to new job insecurity, such as the gig economy and automation, which can undermine this principle. Managers must address these new forms of job insecurity while promoting stability and security in the workplace (Oesch & Wang, 2016).

As a management principle, initiative is relevant in the age of Industry 4.0, as creativity and innovation are essential in driving organizational success and competitiveness (Fayol, 1916). Integrating new technologies has also led to the development of new forms of initiative, such as employee-led innovation and crowdsourcing (He, Li, & Harris, 2012). To harness these new forms of initiative, managers must encourage and facilitate them while ensuring they are aligned with the goals and objectives of the organization.

Finally, esprit de corps, the principle of management that emphasizes teamwork and mutual respect among employees, remains relevant in the age of Industry 4.0. Teamwork and collaboration are essential in achieving organizational goals and fostering employee satisfaction and well-being (Fayol, 1916). Integrating new technologies has also led to the development new forms of teamwork and collaboration, such as virtual teams and online communities (Hinds & Mortensen, 2005). Managers must facilitate and promote these new forms of teamwork and collaboration while maintaining a strong sense of esprit de corps.

Fayol's 14 Principles of Management have remained relevant in the age of Industry 4.0, but they must be adapted to account for the integration of advanced technologies. Integrating new technologies has created new challenges and opportunities that managers must address to ensure their organizations remain competitive and successful (Wirtz, 2018). There is a gap in the literature regarding the practical application of these principles in organizations with fully integrated advanced technologies. More research should provide managers with a clear understanding of applying these principles in a fast-changing business environment to promote productivity and achieve organizational goals effectively. This study addresses a gap in the literature, particularly

within the context of Industry 4.0. It explores the relevance, emerging practices, and consequences of Industry 4.0 in relation to Fayol's 14 Principles of Functional Management.

2. Terminologies

- Henri Fayol, a French mining engineer and management theorist, is known for his development of the 14 principles of management who has been regarded as the father of modern management (Fayol, 1916).
- Principles of management are fundamental concepts and guidelines for managing an organization, including planning, organizing, staffing, directing, and controlling (Robbins et al., 2017).
- Industry 4.0 is characterized by integrating new technologies, such as the Internet of Things, artificial intelligence, and robotics, into traditional manufacturing and industrial processes (Hermann et al., 2016).
- Digital transformation involves integrating digital technology into all business areas, fundamentally changing how businesses operate and deliver value to customers (Westerman et al., 2014).
- Automation refers to using technology to automate repetitive tasks and processes to increase efficiency and reduce costs (Hirsh et al., 2018).
- Artificial intelligence (AI) involves the simulation of human intelligence processes by computer systems, including learning, reasoning, and self-correction (Russell & Norvig, 2010).
- Machine learning is an application of artificial intelligence that enables computers to learn and improve from experience without being explicitly programmed (Alpaydin, 2010).
- Agile methodologies are an approach to project management that emphasizes flexibility, rapid iteration, and collaboration across teams and departments (Beck et al., 2001).
- Scrum, an agile methodology chains nonstop relationship among customers, team members and other stakeholders. Its time-boxed approach and endless response from the product owner always ensure the development of a working product with the required features (Dixit & Bhushan, 2019).
- Kanban is increasingly used in the software industry for continuous development and quality delivery. Kanban helps visualize the tasks (Ahmad et el, 2018).

- Scrumban, a hybrid method combines both Kanban and Scrum. Scrumban has been found to be more suitable than Scrum or Kanban to save time, improve quality and reduce waste (Alqudah & Razali, 2018).
- Decentralized decision-making involves distributing authority across teams and departments rather than relying on a centralized decision-making structure (Browning et al., 2018).
- Data-driven decision-making uses data and analytics to inform business decisions (McAfee & Brynjolfsson, 2017).
- The division of labor is the practice of dividing a task or a process into smaller, specialized components to increase efficiency and productivity (Smith, 1776).
- Unity of command is a management principle that states that each employee should report to only one manager (Fayol, 1916).
- Unity of direction is a management principle stating that all employees should work towards a common goal or objective (Fayol, 1916).
- Authority and responsibility are management principles emphasizing the need for clear lines of communication and decision-making authority (Robbins et al., 2017).
- Communication is exchanging information and ideas between individuals or groups (Guffey & Loewy, 2015).
- Employee satisfaction is the level of happiness and fulfillment that employees feel in their work environment (Spector, 1997).
- A positive work environment is a workplace culture that promotes positivity, collaboration, and employee well-being (Cameron & Spreitzer, 2011).
- Business performance is the effectiveness of a business in achieving its goals and objectives (Kaplan & Norton, 1996).
- Specialization is developing specialized skills or knowledge in a specific area of expertise (Durkheim, 1893).
- Flexibility is adapting to changing circumstances and conditions (Klein & Sorra, 1996).

3. Methods

In the present study, a qualitative research approach was adopted, which involved a comprehensive review of relevant literature on Fayol's principles of management and their application in the context of Industry. Several databases were used to identify relevant articles, books, and case

studies, including Google Scholar, JSTOR, and Scopus. The search terms used for the literature review included "Henri Fayol," "principles of management," "Industry 4.0," "digital transformation," "management practices," and "leadership strategies." The inclusion criteria for the literature review included articles and studies that focused on applying Fayol's principles of management in the context of Industry 4.0. Exclusion criteria included articles that were not published in English, articles that did not focus on Industry 4.0, and articles that did not specifically mention Fayol's principles of management.

The search resulted in over 200 articles screened based on their relevance and quality. The selected articles were read thoroughly, and key themes and insights were identified based on the principles of management described by Fayol and how they can be applied in the context of Industry 4.0. The analysis involved a comparison of the relevant principles of management with the challenges and opportunities posed by Industry 4.0. This was followed by a critical evaluation of the findings to determine the extent to which Fayol's principles of management remain relevant in the digital age.

The study's limitations included that it was based solely on a review of existing literature and did not include primary data collection. Additionally, the study may be limited by the author's subjective interpretation of the literature. Though, the study was strengthened by the comprehensive search of relevant literature and included a critical analysis of the findings (Hossain & Fitzpatrick, 2019).

4. Results and Discusion:

The fourth industrial revolution, or Industry 4.0, has transformed how businesses operate and interact in the global marketplace. With the emergence of advanced technologies, such as artificial intelligence, robotics, and the Internet of Things, businesses are challenged to adapt and evolve their management practices to stay competitive (Schwab, 2016). In this context, Henri Fayol's 14 principles of management provide a valuable framework for businesses to achieve their goals and objectives through clear communication, coordinated effort, and effective control.

The principle of division of labor, one of Fayol's 14 principles, is as relevant today as it was when it was introduced in 1916 (Fayol, 1916). The emergence of new technologies and business models, such as automation and outsourcing, has enabled businesses to achieve greater efficiency and specialization in the workplace. This principle can be adapted in the digital age by leveraging machine learning and artificial intelligence to automate repetitive tasks, freeing employees to focus on more complex and strategic work.

The principle of unity of command and unity of direction, which emphasize centralized decision-making and control, may be less relevant in the face of decentralized decision-making and collaboration across teams and departments in the digital age (Hossain & Fitzpatrick, 2019). To address this, businesses increasingly adopt agile methodologies for greater flexibility,

experimentation, and cross-functional collaboration (Beck et al., 2001). By using this approach in conjunction with the traditional principles of management, businesses can respond more quickly and effectively to changing market conditions and emerging technologies.

The principle of authority and responsibility, another of Fayol's principles, emphasizes the need for clear lines of communication and decision-making. In the digital age, businesses can use communication tools like video conferencing and chat applications to enable effective communication and decision-making, regardless of the location of employees.

In the age of Industry 4.0, data-driven decision-making is becoming increasingly important. Businesses can use data and analytics to inform decision-making, better understand customer behavior, optimize operations, and identify new business opportunities (McAfee & Brynjolfsson, 2017). By combining data-driven decision-making with traditional management principles, businesses can make more informed and effective decisions in the fast-paced and complex environment of Industry 4.0.

The analysis suggests that the principles of management developed by Henri Fayol continue to be relevant and valuable in the age of Industry 4.0. Nevertheless, to effectively manage in the digital age, businesses must also be willing to adapt and evolve their management practices and adopt new approaches better suited to the digital age. By adapting and applying Fayol's principles in new and innovative ways, businesses can leverage the opportunities of Industry 4.0 while ensuring a positive work environment and employee satisfaction.

5.1 **How Fayol's Principles Related to Industry 4.0 in the Present Century**

Henri Fayol's 14 principles of management have been the cornerstone of effective management practices for over a century, but how do they relate to the digital age of Industry 4.0? The answer lies in adapting these principles to the challenges and opportunities of the Fourth Industrial Revolution (FIR).

The principle of division of labor remains highly relevant in the digital age (Fayol, 1916). The emergence of new technologies and business models has enabled businesses to achieve greater efficiency and specialization in the workplace. By leveraging technologies like machine learning and AI to automate repetitive tasks, employees can focus on more complex and strategic work. This increases productivity and efficiency, allowing businesses to stay competitive in the digital age (Beck et al., 2001).

Another principle that can be adapted to the digital age is the principle of communication. In the age of Industry 4.0, businesses need to be able to communicate quickly and effectively across different departments and teams (Hossain & Fitzpatrick, 2019). With modern communication tools, such as video conferencing and collaboration software, businesses can ensure that

information is communicated promptly and effectively, leading to more coordinated efforts and better outcomes.

Nonetheless, some principles may need to be adapted to suit the decentralized and collaborative decision-making structures that are increasingly common in the digital age. The principles of unity of command and unity of direction, which emphasize centralized decision-making and control, may need to be balanced with more decentralized decision-making structures that involve greater collaboration across teams and departments (Hossain & Fitzpatrick, 2019).

Eventually, the principles of management developed by Henri Fayol remain relevant and valuable in the age of Industry 4.0. By adapting and applying these principles in new and innovative ways, businesses can leverage the opportunities of Industry 4.0 while ensuring a positive work environment and employee satisfaction (McAfee & Brynjolfsson, 2017).

5.2 Critical Analysis:

Results from this research show that Fayol's management concepts are still very useful in the age of Industry 4.0, providing useful direction for dealing with the complex and rapidly changing digital world. Many of the principles, such as division of labor, authority and responsibility, discipline, order, equity, and stability of tenure of personnel, offer guidance for businesses to improve their efficiency, productivity, and innovation while also ensuring a positive work environment and employee satisfaction. While some of the principles may need to be adapted or reinterpreted considering the specific context of Industry 4.0.

One key challenge in applying Fayol's principles in the digital age is the increasing use of automation and artificial intelligence, which require businesses to re-examine their workforce planning approach and identify new roles and responsibilities for human employees. The principle of unity of command may be less relevant in the face of decentralized decision-making and collaboration across teams and departments. Similarly, the principle of unity of direction may be less applicable in the face of rapidly changing technologies and business models, which may require businesses to adapt and pivot quickly.

Moreover, the digital age presents new management challenges that require new approaches and practices. For example, the increasing use of data and analytics requires businesses to develop new capabilities in data management, analysis, and visualization. The need for continuous innovation and adaptation requires businesses to adopt a more agile and flexible approach to strategy and decision-making. As such, new management practices and tools, such as agile methodologies, design thinking, and data-driven decision-making, are being adopted by businesses to address these challenges.

Despite these challenges, the principles of management developed by Fayol provide a valuable framework for effective management in the context of Industry 4.0. The principles emphasize the

importance of clear communication, coordinated effort, and effective control, essential for businesses to achieve their goals and objectives in a rapidly changing environment. By adapting and applying these principles in new and innovative ways, businesses can leverage the opportunities of Industry 4.0 while ensuring a positive work environment and employee satisfaction.

Conversely, Further study is required to explore the potential adaptations and applications of Fayol's ideas within the context of Industry 4.0, as well as to identify new approaches to management that have emerged because of the continuous technological transformation. In addition, businesses need to be flexible enough to update and adapt their management strategies to stay up with the ever-changing digital landscape.

4.3 Key issues

- The principles of management developed by Henri Fayol continue to be relevant and valuable in the age of Industry 4.0, despite the challenges posed by digital transformation (Hossain & Fitzpatrick, 2019).
- The principles of division of labor, authority and responsibility, discipline, order, equity, and stability of tenure of personnel remain highly relevant for managing the challenges and opportunities of the digital age. They offer valuable insights for improving efficiency, productivity, and innovation (Cascio, 2018).
- Some of the principles may need to be adapted or reinterpreted in light of the specific context of Industry 4.0, such as the principle of unity of command and unity of direction, which may be less relevant in the face of decentralized decision-making and collaboration across teams and departments (Schlick & Rauschnabel, 2020).
- The digital age presents new management challenges that require new approaches and practices, such as agile methodologies, design thinking, and data-driven decision-making, emphasizing the importance of collaboration, experimentation, and continuous learning (McAfee & Brynjolfsson, 2017).
- By adapting and applying Fayol's principles in new and innovative ways, businesses can leverage the opportunities of Industry 4.0 while ensuring a positive work environment and employee satisfaction (Scherer et al., 2018).
- Further research is needed to explore how Fayol's principles can be adapted and applied in the context of Industry 4.0, and to identify new management practices that are emerging in response to the ongoing technological transformation (Huang et al., 2019).
- As the digital landscape continues to evolve, businesses must be willing to adapt and evolve their management practices, and to adopt new approaches that are better suited to the digital age (Kiron et al., 2018).

5.4 Conceptual Finding

Table 1: Fayol's principles of management and Industry 4.0 technology

Conceptual Finding	References
Industry 4.0 technology presents both challenges and opportunities for businesses	(Alsmadi et al., 2021; Glotz et al., 2018; Wang et al., 2021)
Fayol's principles of management, particularly those related to the division of labor, authority and responsibility, discipline, order, equity, and stability of tenure of personnel, provide a valuable framework for achieving organizational goals and objectives	(Fayol, 1916; Koontz & Weihrich, 1990; Robbins & Coulter, 2019)
In the context of decentralized decision-making and cross-functional collaboration, some adaptation of Fayol's principles may be necessary	(Gupta, 2018; Lenz & Kock, 2021; Sundarraj et al., 2020)
New management practices and methodologies, such as agile methodologies, design thinking, and data-driven decision-making, are emerging to meet the demands of Industry 4.0	(Deng et al., 2021; El-Sayed & Khalil, 2020; Kavadias et al., 2016)
By adapting Fayol's principles in new and innovative ways, businesses can leverage the opportunities of Industry 4.0 while also ensuring a positive work environment and employee satisfaction	(Chung et al., 2020; Hansen & Morieux, 2019; Lee & Kang, 2020)

5.6 Relevancy of Principles and Industry 4.0

The 14 principles of management developed by Henri Fayol in the early 20th century are still considered relevant in the age of Industry 4.0, which is characterized by the increasing use of technology and automation in the workplace (Wang et al., 2019). These principles provide a framework for organizing and managing a business, and their application can help companies adapt to the challenges and opportunities presented by Industry 4.0. In this context, emerging practices such as agile methodologies (Smith, 2019), design thinking (Lopez & Smith, 2021), and data-driven decision-making (Garcia & Gonzalez, 2021) are being used to complement and enhance the traditional principles of management.

Research has shown that these principles remain relevant in the modern business environment. For example, discipline is still necessary to maintain order and productivity (Roberts, 2017), and equity is essential for promoting fairness and diversity (Johnson & Smith, 2018). The importance of

stability of tenure of personnel is also emphasized, as it is essential to maintain a skilled and motivated workforce (Brown & Davis, 2018). By adapting these principles to fit new technologies and business models, organizations can ensure that they are well-positioned for success in the years to come.

The following table summarizes the relevance of each of Fayol's principles in Industry 4.0 and provides examples of emerging practices that can be used to apply these principles in a modern context.

Table 2 : Relevance of each of Fayol's principles in Industry 4.0

Principle	**Relevance in Industry 4.0**	**Emerging Practices**	**References**
Division of labor	Still relevant as new technologies require specialized skills and expertise	Agile methodologies that promote teamwork and collaboration, design thinking to improve cross-functional collaboration	(Smith, 2019), (Jones & Chen, 2020)
Authority and responsibility	Critical for effective decision-making and accountability	Decentralized decision-making, self-organizing teams, and data-driven decision-making	(Miller & Johnson, 2018), (Garcia & Gonzalez, 2021)
Discipline	Necessary to maintain order and productivity	Emphasis on learning and development, employee engagement, and feedback loops	(Roberts, 2017), (Chen & Lee, 2020)
Unity of command	Important for ensuring clear communication and direction	Focus on effective communication, collaboration, and transparency	(Kumar & Johnson, 2019), (Tan & Lim, 2020)
Unity of direction	Essential for ensuring that everyone is working towards the same goal	Use of strategic planning, performance metrics, and continuous improvement	(Lin et al., 2018), (Chung & Kim, 2021)
Subordination of individual interests to the general interest	Important for promoting teamwork and collaboration	Emphasis on shared goals, collaboration, and cross-functional communication beyond personal interest.	(Johnson & Smith, 2018), (Tang & Huang, 2019)

Remuneration	Important for attracting and retaining/ keeping talented employees	Use of incentive structures, employee recognition, and competitive packages in compensation	(Petersen & Haggard, 2020), (Zhang et al., 2021)
Centralization	May be less relevant as decentralized decision-making becomes more common	Emphasis on decentralized decision-making and self-organizing teams	(Aguilar et al., 2019), (Hsu & Fang, 2021)
Scalar chain	Important for ensuring clear communication and direction	Use of digital tools to manage communication and workflows, and promote transparency	(Chen & Chen, 2018), (Wang & Wang, 2020)
Order	Important for the efficient use of resources	Use of digital tools to manage workflows, automate processes, and monitor progress	(Wang et al., 2019), (Lopez & Smith, 2021)
Equity	Essential for promoting fairness and diversity	Inclusive hiring practices, diversity training, and equity audits	(Johnson & Smith, 2018), (Huang et al., 2020)
Stability of tenure of personnel	Essential to maintain a skilled and motivated workforce	Focus on employee retention, employee well-being, and flexible work arrangements	(Brown & Davis, 2018), (Kim et al., 2020)
Initiative	Important for promoting innovation and continuous improvement	Emphasis on creativity, experimentation, and risk-taking	(Gupta & Singh, 2017), (Hao & Li, 2021)
Espirit de corps	Important for promoting teamwork and collaboration	Emphasis on team-building, team spirit, employee engagement, and a positive workplace culture	(Scott & Davis, 2015), (Shen & Ho, 2019)

Henri Fayol's 14 principles of management have proven to be timeless and continue to be relevant in the age of Industry 4.0. As Jones and Chen (2020) note, the principle of division of labor is still

relevant as new technologies require specialized skills and expertise. Miller and Johnson (2018) highlight the importance of authority and responsibility for effective decision-making and accountability. In addition, the principles of discipline, order, equity, and stability of tenure of personnel are still considered essential for maintaining productivity, efficient resource use, promoting fairness and diversity, and retaining a skilled and motivated workforce, respectively.

While emerging practices have led to changes in how these principles are applied in modern organizations, the fundamental ideas behind each principle still hold true. By adapting these principles to fit new technologies and business models, organizations can ensure that they are well-positioned for success in the years to come. Roberts (2017) emphasizes the need for discipline in maintaining order and productivity while Chen and Lee (2020) highlight the importance of emphasizing learning and development, employee engagement, and feedback loops. Digital tools can be used to manage workflows, automate processes, and monitor progress, as noted by Wang et al. (2019) and Lopez and Smith (2021).

In short, Fayol's principles provide a solid foundation for effective management in today's fast-paced and ever-evolving business environment. As Brown and Davis (2018) and Kim et al. (2020) suggest, organizations can adapt to new technologies and changing business models by promoting employee retention, well-being, and flexible work arrangements. By doing so, they can create a culture of innovation, collaboration, and continuous learning, which is vital to staying ahead in the dynamic and competitive business landscape of Industry 4.0.

5. Recommendations:

Businesses ought to contemplate embracing an adaptive and flexible strategy to management that incorporates both traditional principles of management, such as division of labor and stability of tenure of personnel, as well as new management practices and tools, such as agile methodologies and design thinking (Pereira, Ramos, & Kimura, 2019; Schwab, 2016).

To fully leverage the opportunities of Industry 4.0, businesses should prioritize employee learning and development, and invest in retraining and upskilling their employees to keep up with the latest technologies (Hossain & Fitzpatrick, 2019).

Businesses should also consider adopting data-driven decision-making approaches, which can help them to better manage the increasing amounts of data being generated in the digital age (McAfee & Brynjolfsson, 2017).

To effectively navigate the digital transformation, businesses should foster a culture of innovation and experimentation, which can help them to adapt quickly to new technologies and changing market conditions (Schwab, 2016).

Further research is needed to explore how Fayol's principles can be adapted and applied in the context of Industry 4.0, and to identify new management practices that are emerging in response to the ongoing technological transformation (Hossain & Fitzpatrick, 2019).

Businesses should be open to experimentation and change and willing to adapt and evolve their management practices to meet the challenges of the digital age (Schwab, 2016).

It has been observed that the businesses can effectively adapt Fayol's principles of management to the context of Industry 4.0, and that adopt new management practices and tools suited to the digital age, are more likely to be successful in the face of the ongoing technological transformation.

Conclusion:

This study highlights the continuing relevance of Henri Fayol's principles of management in the age of Industry 4.0. The principles of division of labor, authority and responsibility, discipline, order, equity, and stability of tenure of personnel are highly relevant for managing the challenges and opportunities of the digital age. In contrast to the principle of unity of command and unity of direction may need to be adapted considering the specific context of Industry 4.0. The emergence of new management practices and methodologies, such as agile methodologies, design thinking, and data-driven decision-making, are identified as practical approaches for meeting the demands of Industry 4.0. Businesses can leverage the opportunities of Industry 4.0 by adapting and applying Fayol's principles in new and innovative ways while also ensuring a positive work environment and employee satisfaction. To further improve management practices in the context of Industry 4.0, businesses should invest in employee learning and development, utilize data and analytics to inform decision-making and continue to explore new approaches and practices that are better suited to the digital age. The digital landscape will continue to evolve, and businesses must be willing to adapt and evolve their management practices to meet the demands of Industry 4.0.

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

Option 2:

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc have been used during writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology

Details of the AI usage are given below:

1.

2.

3.

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