Issues in Informing Science + Information Technology

An Official Publication of the Informing Science Institute InformingScience.org

IISIT.org

Volume 21, 2024

EVOLUTION OF INFORMATION TECHNOLOGY IN INDUSTRY: A SYSTEMATIC LITERATURE REVIEW

Siddique Abubakr Muntaka*	University of Cincinnati, Cincinnati, OH, United States	muntaksr@mail.uc.edu
Joel Kwesi Appiah	University of Cincinnati, Cincinnati, OH, United States	appiahjk@mail.uc.edu
Hazem Said	University of Cincinnati, Cincinnati, OH, United States	saidhm@ucmail.uc.edu

* Corresponding author

ABSTRACT

Aim/Purpose	This study addresses the research question: "What are the developmental phases of Information Technology in the industry?" Existing research has explored the impact of Information Technology (IT) on specific industries. However, it is essential to understand the evolution of IT within industries, its influence on the workforce, and technological advancements. Addressing this knowledge gap will enhance future workforce development and IT integration across diverse sectors.
Background	IT can significantly transform industries and drive innovation to meet client demands. Understanding IT phases in industry through literature helps governments and businesses worldwide recognize its importance. This knowledge can guide strategies to address the shortage of highly skilled workers by prioritizing education and training programs to meet future demands.
Methodology	The methodology involved a systematic literature review of 110 IEEE Xplore, ACM Digital Library, and Google Scholar articles. Thematic analysis was used to understand the development of IT in distinct phases since the 1990s. This development has resulted in a continuous demand for new workforce skills and evolving customer expectations.
Contribution	This study aims to fill the knowledge gap by enhancing our understanding of how evolving IT influences the industry and shapes IT jobs and skills. It provides a historical perspective, illustrating how IT advancements have led to new applications to meet changing needs. Additionally, the study identifies patterns

Accepting Editor: Eli Cohen | Received: January 29, 2024 | Revised: June 5, 2024 | Accepted: Jume 8, 2024
Cite as: Muntaka, S. A., Appiah, J. K., & Said, H. (2024). Evolution of the information technology in industry: A systematic literature review. *Issues in Informing Science and Information Technology, 21,* Article 7.
https://doi.org/10.28945/5316

	in the evolving IT skill requirements due to technological advancements and discusses implications for curriculum development and higher education.
Findings	The study identified three significant phases through a systematic literature review and thematic analysis. The first phase, "Advent of Industry IT" (1990-2000), established the digital framework and built essential systems and infrastructure. The second phase, "Connectivity & Information Revolution" (2000-2010), saw exponential internet growth, transforming information access and communication. The third phase, "Emerging Industry IT" (2010-present), focuses on artificial intelligence, automation, and data-driven insights, continuing to disrupt and transform industries.
Recommendations for Practitioners	The changing phases of IT within the industry should inform the development of innovative programs. These programs should address diverse skill sets across eras, preparing the workforce for evolving job roles in various sectors, such as healthcare in North America, automotive manufacturing in Japan, telecommunications in Africa, and innovations in other parts of the world.
Recommendations for Researchers	Researchers can conduct longitudinal studies to explore the ongoing evolution of IT, tracking its trajectory beyond current delineated phases to understand future trends. Comparative studies across various industries can assess how IT evolution varies among sectors and delve deeper into its practical implications. Researchers can also conduct impact assessment studies to determine how various IT phases directly affect organizational strategy, worker dynamics, and organizational structures across industries. Examples include logistics in the Netherlands, retail in the United Kingdom, and agriculture in Brazil.
Impact on Society	Policymakers and planners can use knowledge of these phases to predict technological shifts and industry trends. This knowledge helps develop strategies and policies supporting entrepreneurship, education and training alignment, technical innovation, economic growth, and job creation in line with the changing IT landscape. Examples of policies include Singapore's Smart Nation initiative, Germany's Industry 4.0 strategy, Ghana's digitization efforts, and India's Digital India campaign.
Future Research	Future research can provide a thorough understanding of the evolutionary patterns of IT within sectors by validating the study through various datasets and conducting in-depth examinations of individual industries. This will contribute to a deeper understanding of sector-specific IT evolution and their varying impact on societal interactions and industry dynamics. Comparative studies across various sectors, such as logistics in the Netherlands, retail in the United Kingdom, and agriculture in Brazil, can assess how IT evolution varies.

Keywords	information technology, evolution of information technology, industry and information technology, phases of information technology

INTRODUCTION AND BACKGROUND

Industries worldwide have undergone continuous transformation marked by several phases (Koh et al., 2019). Over the years, developments in IT have led to new technologies and processes that are reshaping industries globally (Păvăloaia & Necula, 2023). This phenomenon is caused by several driving factors, including research and development efforts, the push for competitiveness, and the insatiable consumer appetite for more advanced and efficient products and services (Farida & Setiawan,

2022). The interplay of these factors results in an ever-unfolding narrative of change and adaptation within industries.

According to Hoyer et al. (2020), the industry's ability to meet its customers' needs is strongly related to its ability to adopt information technologies that can cope with society's ever-insatiable needs. Globally, industries and government leaders are recognizing the significance of information technology and are facing the challenge of a shortage of highly trained workforce (Nithithanatchinnapat & Joshi, 2019). Said et al. (2021) defined information technology as "the study of solutions and needs that connect people, information, and the technology of the time." Said et al. further assert that this definition requires IT professionals with the knowledge, tools, and skills to collaborate with stakeholders effectively and provide the right solutions.

Information technology is an independent discipline, entirely different from information science, computer science, and computer engineering (Basty et al., 2023). Several studies have explored the impact of IT on specific industries. Lu et al. (2015) conducted an in-depth review of publications over the past 15 years, asserting that IT strongly impacts the growth of global architectural, engineering, and construction (AEC) businesses. The construction industry is well-suited to use IT for competitive and operational benefits, as technology adoption happens quickly (Bello et al., 2021). Similarly, cloud computing technologies, an emerging trend in IT, have transformed many industries (Saini et al., 2019). Information technology has significantly contributed to productivity increases in various countries, including the United States, by enhancing productivity through cost reduction, quality improvement, acceleration of processes, and facilitation of new business models (Lopez-Vega & Moodysson, 2023; Stiroh, 2001).

Firms and industries worldwide, including those in Sweden, Japan, Saudi Arabia, and China, have been significantly impacted by technology (Alghamdi & Aboalela, 2023; Vigren et al., 2022). IT has significantly influenced various sectors globally, including the banking industry, manufacturing, hospitality, and tourism, as evidenced in numerous studies (Khatri, 2019; Mocetti et al., 2017). The manufacturing sectors worldwide, especially in Japan, have seen tremendous growth through robotics and automation by leveraging technology (Kemelhor, 1987). In Japan, the integration of IT into the automotive sector has been heavily influenced by the country's emphasis on precision, efficiency, and continuous improvement (Li et al., 2024). Similarly, the Industry 4.0 concept in Germany reflects a cultural commitment to engineering excellence and innovation. This drives the development of smart factories and advanced manufacturing technologies (Felser & Wynn, 2020). The automotive industry in Germany has benefited from IT advancements in manufacturing processes (Krzywdzinski, 2021).

While there has been much discussion on how IT is shaping specific industries and countries with industrialization and productivity, the researchers observed little research exploring the developmental phases or evolution of IT in the industry. Understanding the evolution of IT in the industry would first enhance our understanding of the influence of evolving IT on the nature of IT jobs and skills. It also offers a historical view that shows how the insights and accomplishments of IT development led to new applications to satisfy changing needs. Lastly, it can assist in determining the trend of change in the skills needed for IT jobs and offer implications, particularly for curriculum creation and university education, to close the skills gap in the labor market.

Our study aims to address this research gap by investigating the development phases of information technology. This will provide a comprehensive understanding of the phases of IT's evolution in the industry and inform strategies for workforce development, education, and IT integration across diverse sectors. The study will guide future research and policymaking by identifying key trends and shifts in IT. Hence, the research question for this study is:

What are the developmental phases of Information Technology in the industry?

This systematic literature review spans the years 1990 to 2023, examining peer-reviewed articles that focus on the evolution of IT. The paper is structured as follows. The first section sets the theoretical

background and justifies the study's necessity. The next section details our methodology. The findings are then presented, followed by a discussion of their implications.

METHODOLOGY

This study employs a systematic literature review (SLR) methodology using the Kitchenham and Charters framework (Kitchenham et al., 2006). The SLR method involves a rigorous, transparent, and replicable process for identifying, evaluating, and synthesizing relevant literature (Koh et al., 2019). The Kitchenham and Charters framework structures the SLR process into three phases: planning, conducting, and reporting the review (Kitchenham et al., 2006).

Xiao and Watson (2019) assert that the conduct of a systematic literature review heavily relies on the breadth and quality of the studies included. Therefore, the Kitchenham and Charters framework was selected for this study due to its comprehensive approach, which extends beyond the mere establishment of methods to ensure transparency and completeness through rigorous inclusion and exclusion criteria. This framework is well-known in academia for conducting reviews in various fields (Kitchenham et al., 2006; Kumar et al., 2022).

This study employed three academic databases: IEEE Xplore, ACM Digital Library, and Google Scholar. These databases were selected for their comprehensive global research coverage and because they primarily focus on technology-related literature and contain a vast collection of conference papers and peer-reviewed articles from fields like information technology, computing, and engineering, making them well-suited for this study (Valente et al., 2022). Study papers were selected based on the inclusion and exclusion criteria described in Table 1.

Table 1. Inclusion and exclusion criteria

Inclusion	Exclusion
Articles describing the history of IT in the industry	Articles written in a language other than English
Articles describing the application of IT in industry	Articles on selected industries
Peer-reviewed articles	Articles on academic programs

SEARCH PROCESS

Formulating effective search terms for our literature review was challenging due to the varying approach to search terms used by different academic databases. After several iterations to find the appropriate search query, Figure 1 shows the final queries used.

IEEE Xplore Query ("All metadata": industry Information technology trends)

ACM Digital Library Query ("All Metadata": industry Information technology trends)

Google Scholar Query ("All Metadata": industry Information technology trends)

Figure 1. Search query

The search was conducted using the queries in Figure 1 on Thursday, October 26, 2023, by accessing the IEEE Xplore, ACM digital library, and Google Scholar databases. The search returned 1,002 articles, which were exported to Rayyan software. Rayyan is a web-based software for accelerating systematic literature reviews developed by the Qatar Computing Research Institute (QCRI), and it is freely available to use (Ouzzani et al., 2016). The query results, as shown in Table 2, were exported to the Rayyan Software (https://www.rayyan.ai/). Using Rayyan software, 111 duplicate studies were automatically removed, leading to 891 papers remaining.

Table 2. Articles retrieved from databases

Source	Number	Duplicate
IEEE Xplore	500	
ACM Digital Library	402	
Google Scholar	100	
Total	**1002**	**111**

The inclusion and exclusion criteria were manually applied to the title of the articles. The researchers blindly screened each article using titles and abstracts to reduce the tendency of biases. In cases where all reviewers rejected a study, the article was rejected outright. When either of the reviewers rejects a study, the study is then read and discussed to make a final decision. A study is outright included if all reviewers accept the article. After completing the screening process, 110 potential studies were identified. This represents 12.3% of the identified study papers used for the primary study. The complete list of articles is found in Appendix A.

Quality Assessment

Following Kitchenham and Charters systematic review framework (Kitchenham et al., 2006), the quality of each paper was assessed by critically reviewing the abstracts and introductions based on the quality criteria outlined in Table 3. Each author conducted a blind assessment of the abstracts and introductions of the articles. The objective was to ascertain if the content aligned with the research focus. Subsequently, the authors categorized the articles based on each reviewer's determination regarding their relevance to the study. When discrepancies arose among reviewers, collaborative discussions were initiated among the authors. These discussions aimed to resolve disagreements and achieve a consensus on the appropriate categorization and labeling of the articles. Figure 2 shows the output of Rayyan Software as used by the authors. A scale of 100% was applied and shared among the 110 research papers. The paper was graded from less focus, some focus, to most focus, based on how close the abstract is to the research question and the aim of the study.

Table 3. The quality assurance criteria

	Less focus [42]	Some focus [44]	Most focus [24]
To what degree does the article focus on the development of information technology in the industry	42(38.2%)	44(40%)	24(21.8%)

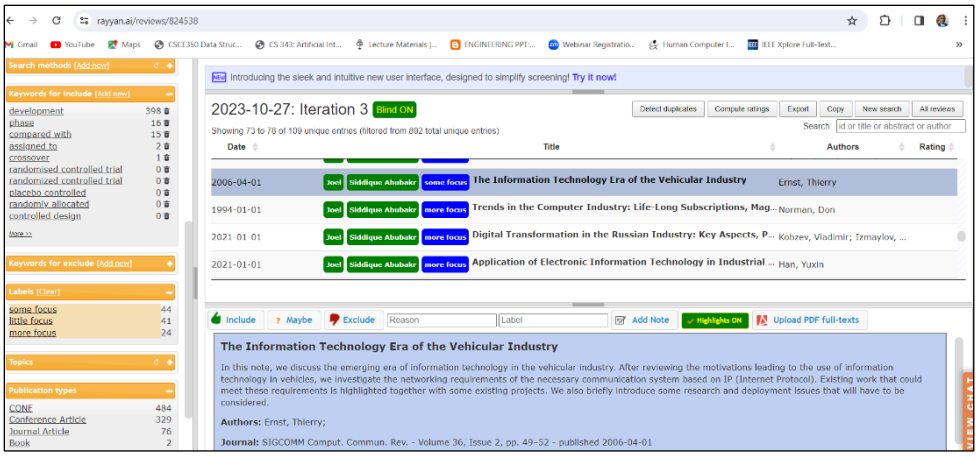

Figure 2. Rayyan software output

Based on the quality assessment and combining the some-focused and most-focused categories, 61.8% of articles focused on the phases of IT in the industry, and 38.2% had less focus on these phases. The authors considered the quality assessment outcomes in the synthesis and analysis to ensure that the findings and conclusions drawn are based on studies of sufficient quality.

THEMATIC ANALYSIS

The abstracts of the study articles were analyzed using thematic analysis. Lochmiller (2021) defines thematic analysis as "a method for identifying, analyzing, and reporting patterns (themes) within data." The thematic analysis process allowed the researchers to determine the relationships between concepts and compare them. The three-stage protocol outlined by Thomas and Harden (2008) was applied to the text of each article:

1. **Initial Coding:** The text in the papers was coded line-by-line. The researchers developed a script using RStudio version 2023.09.00 Build 463 to scan the entire articles line-by-line. The script identified repeating words and listed them with their word count in a bar chart to facilitate the analysis of the phases of evolution for IT. The 110 articles were initially subgrouped by publication years. Initial codes were generated from words extracted by RStudio in each phase. The script is in Appendix C.
2. **Descriptive Themes:** Descriptive themes closely linked to the articles were generated. Words with similar content or meaning were grouped (e.g., 'industry' and 'organization or business' were related codes that could be grouped). An additional step was taken to combine words that appeared to be the same due to their singular, plural, or contextual meanings, such as 'industry' and 'industrial' and 'technology' and 'computing.'
3. **Analytical Themes:** The researchers developed final analytical themes that create new explanations or hypotheses. To confirm the themes, they had a consensus meeting. During this meeting, the researchers presented and explained their themes and then agreed on the final theme.

The research team determined that analyzing papers published within each phase is necessary to identify the themes and answer the research question. The selected primary study articles span from 1990 to 2023, with varying levels of evolution activities. The years 1990, 2000, and 2010 were critical points in the time frame to place the IT evolution activities in context. These years marked three decades, which the authors observed is a significant time for technology to emerge. According to Hirschheim and Klein (2012), the history of IT is often classified in terms of 'generations,' 'phases,' or 'eras.' Consistent with this characterization by Hirschheim and Klein's framework, we draw upon these computing eras to facilitate our discussion. The authors, therefore, adopted a decade time frame for each phase, as used by Hirschheim and Klein.

Using RStudio, the articles were grouped by year for each phase and coded separately. The team faced challenges with graph legibility due to varying word counts, prompting experiments with different thresholds. Through iterative testing, optimal word counts were determined. Word counts below certain thresholds were excluded to maintain diagram legibility, as these counts were considered insignificant. The counts were selected through a randomized approach to ensure optimal visualization in the graphical outputs. Additionally, the team reviewed, discussed, compared, and merged words with similar meanings, deleting irrelevant ones. Words with total counts of 50, 60, and 600 for each respective phase represented the codes generated by R, establishing thresholds of $n >= 50$, $n >= 60$, and $n >= 600$, where 'n' represents the frequency of the words.

The researchers followed the iterative process of reading and refining the codes until reaching the themes. Once a general phrase was identified, it was evaluated, and it was decided if it could be used as a theme. Words with similar content or meaning were grouped. An additional step was taken to combine words that appeared to be the same due to their singular, plural, or contextual meanings, such as 'industry' and 'industrial' and 'technology' and 'computing.' The researchers had a consensus meeting to confirm the identified themes. This process ensured a more accurate thematic analysis.

Ensuring Reliability and Validity

To ensure the reliability and validity of the thematic analysis, the following measures were taken:

1. *Inter-Rater Reliability:* Multiple researchers independently coded the data and compared their results to ensure consistency. Any discrepancies were resolved through discussion and consensus.
2. *Member Checking:* An external expert reviewed the themes identified to validate the findings and ensure they accurately represented the data.
3. *Audit Trail:* Detailed documentation of the coding process was recorded to provide a transparent audit trail.

RESULTS

The illustration in Figure 3 shows the trends of publications, encompassing articles published between 1973 and 2023. Notably, more than half of these studies were published after 2010. This highlights a recent surge in academic interest regarding the evolution of Information Technology in various industries. This systematic literature review is thus timely, reflecting the increasing number of scholarly papers on this topic. The authors selected 110 papers for this study by applying rigorous inclusion and exclusion criteria. These chosen papers span from 1990 to 2023, providing a comprehensive overview of IT evolution over the past few decades.

The authors present the findings of the thematic analysis. The dataset is divided into three major themes: Advent of Industry IT, Connectivity & Information Revolution, and Emerging Industry IT. The authors examine each theme in detail.

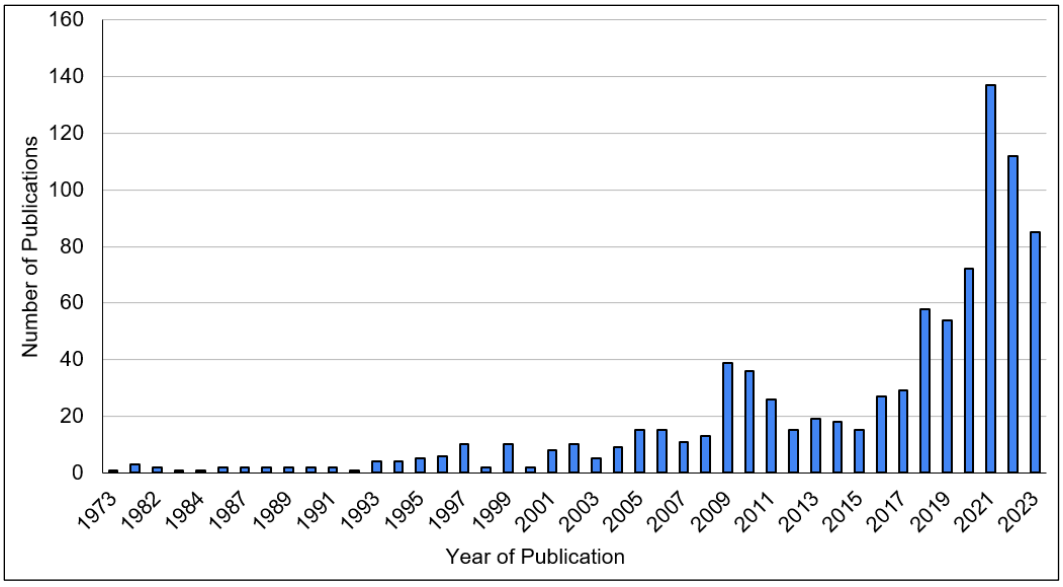

Figure 3. Publications distribution by year

The diagrams in Figures 4, 5, and 6 illustrate the most frequently occurring words for phases 1 to 3, which helped create the themes. In Phase 1, the top-occurring words included 'information,' 'systems,' 'knowledge', and 'industry.' Based on these findings, this phase was named 'Advent of Industry IT.' In Phase 2, the prevailing words such as 'data,' 'industry,' 'internet,' 'digital,' 'email,' 'integration,' and 'networks' led to the theme 'Connectivity & Information Revolution.' In Phase 3, words like 'data,' 'digital,' 'internet,' and 'analysis' supported the theme 'Emerging Industry IT.' Final codes for each phase and their main themes are summarized in Tables 4 and 5, with detailed information in Appendix B.

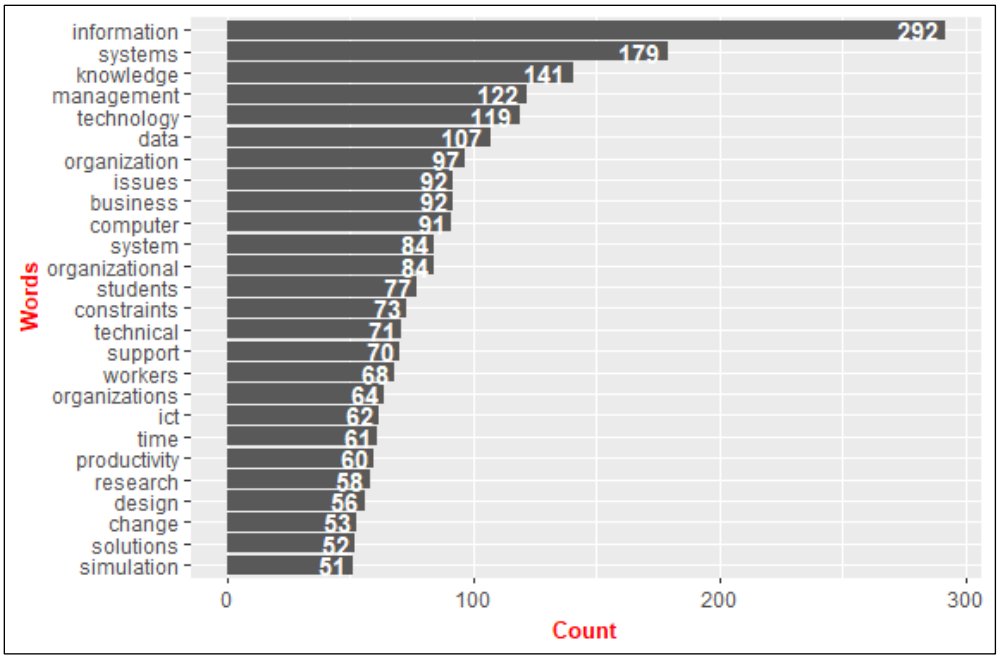

Figure 4. Repeated words with a wordcount of n >= 50 in phase 1 generated in RStudio Version 2023.09.0 Build 463

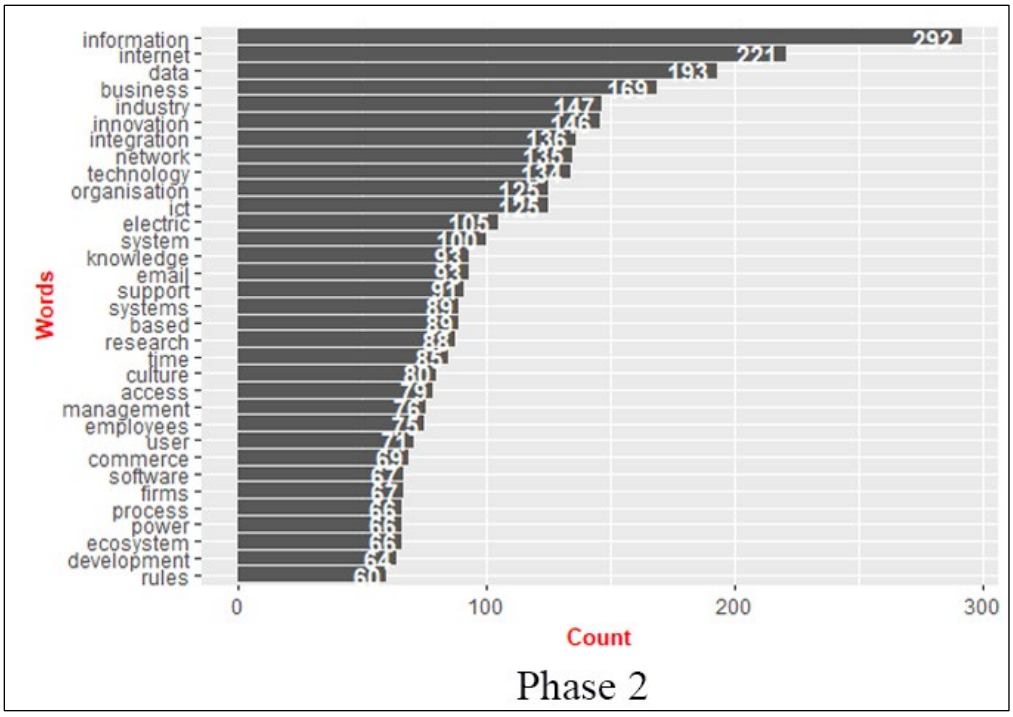

Figure 5. Repeated words with a word count of n >= 60 in phase 2 generated in RStudio Version 2023.09.0 Build 463

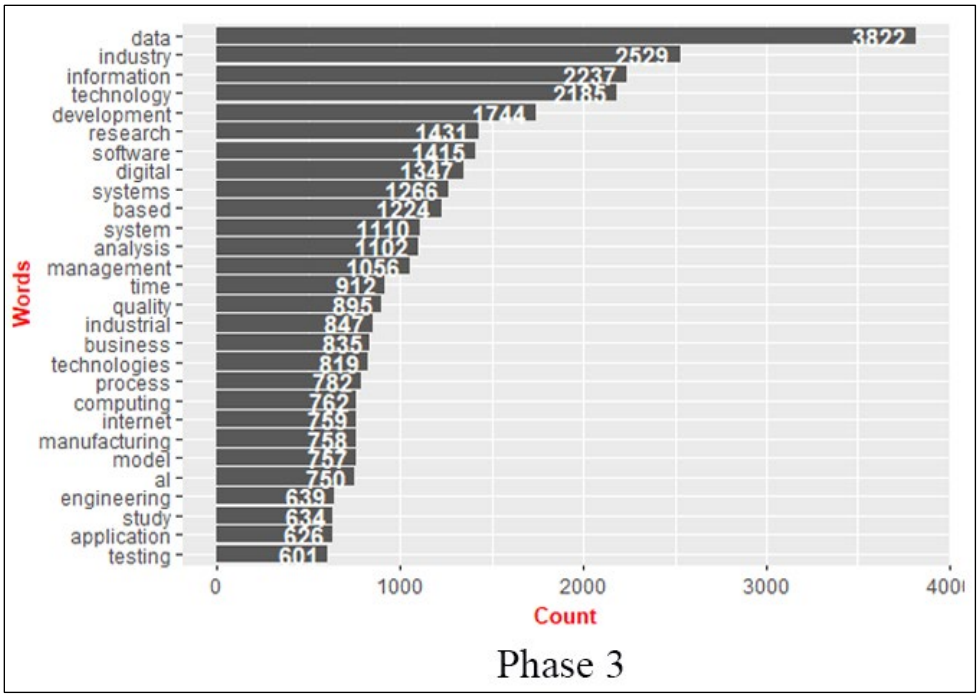

Figure 6. Repeated words with a word count of n >= 600 in phase 3 generated in RStudio Version 2023.09.0 Build 463

Table 4. Thematic analysis

Word	Definition	Year	Theme
information	Insights relevant to the workplace	1990	Advent of Industry IT
system	Desktop computers and applications	1995	Advent of Industry IT
knowledge	Industry daily data	1993	Advent of Industry IT
computer	PC's & mainframe	1999	Advent of Industry IT
data	Raw facts relevant to the analysis	2005	Connectivity & Information Revolution
industry	The sector of economic activity	2008	Connectivity & Information Revolution
Internet	A global network of computers	2009	Connectivity & Information Revolution
technology	Practical application of science	2009	Connectivity & Information Revolution
data	Intensive information	2012	Emerging industry IT
information	Large daily reports	2015	Emerging industry IT
research	Look into new ways like automation	2021	Emerging industry IT
digital	Related to computer technology	2020	Emerging industry IT

Table 5. The dominant theme with the metadata for each article

Theme	Year
Advent of Industry IT	1990 - 1999
Connectivity & Information Revolution	2000 - 2010
Emerging industry IT	2010 - 2023

DISCUSSION AND CONCLUSION

The results showed that Information Technology has evolved mainly in three phases over the years, as shown in Table 4 and Table 5. The first phase of the evolution, as discovered in the study, is termed the "Advent of Industry IT," which occurred between 1990 and 1999. The second phase, the "Connectivity & Information Revolution," occurred between 2000 and 2010. The third phase, "Emerging industry IT," occurred between 2010 and 2023. Figure 7 shows the details.

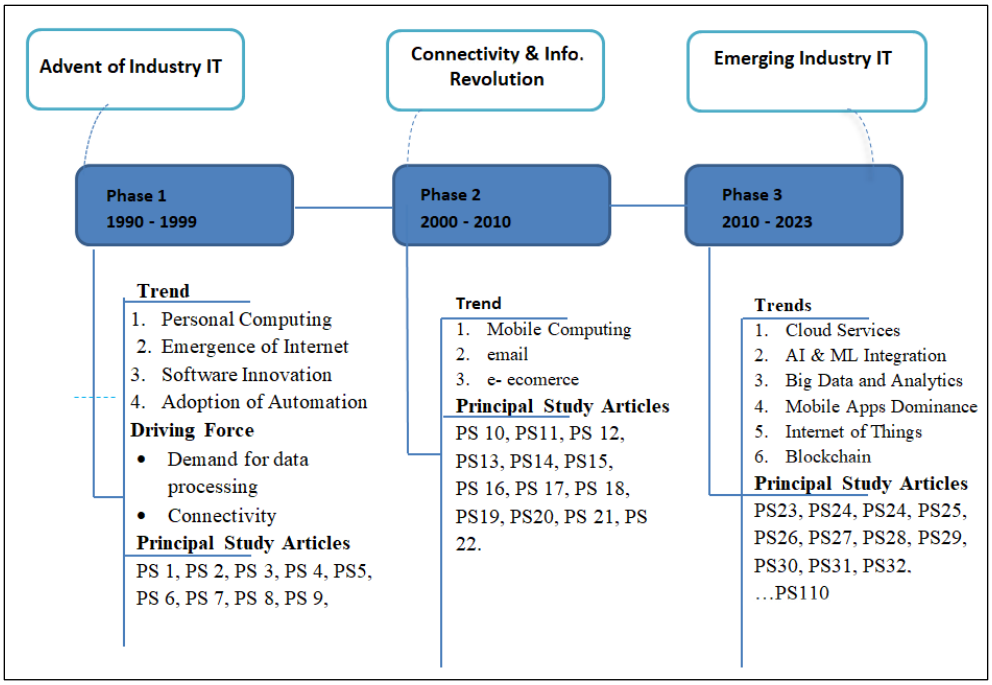

Figure 7. List of articles

PHASE I - ADVENT OF INDUSTRY IT

The first phase of IT evolution, termed the "Advent of Industry IT," marked a period of rapid advancement of electronic information technologies and their integration into global information networks. This pivotal era in IT evolution saw information technology permeating many sectors of the economy, transforming operational practices and organizational frameworks (Lu et al., 2015).

Dominant keywords such as "information," "systems," "data," and "knowledge," identified from study articles PS1 through PS9, suggest that this period was characterized by industries beginning to adapt IT into their operations. The 1990s experienced significant growth in the industry due to the widespread adoption of digital control systems and personal computers (PCs) (Nakano et al., 1991). During this time, industries converted their data and knowledge repositories using desktop and mainframe computers. Early industrial systems emerged, taking over repetitive tasks and enhancing production. These systems revolutionized the industrial landscape and fundamentally changed how organizations managed and made decisions based on data (Peruzzini & Pellicciari, 2018).

The automotive industry, for instance, underwent a significant transformation by adopting computer-aided design (CAD) systems. This technological evolution facilitated the shift from manual drafting to digital design processes, thus enhancing the speed and accuracy of vehicle design. At General Motors, the implementation of CAD systems enabled the rapid prototyping of new vehicle models, significantly reducing the design lifecycle and associated costs (Lu et al., 2015). This phase began IT's pervasive influence in optimizing traditional manufacturing processes and laid the foundation for future innovations.

Phase 2 - Connectivity & Information Revolution

Transitioning from the initial phase, the second phase is termed the "Connectivity & Information Revolution." This witnessed a profound transformation characterized by a shift from legacy systems to network-centric computing (Hirschheim & Klein, 2012). This transition led to increased connectivity, innovation, and a deeper integration of IT into business processes. Consequently, this era saw a surge in the use of vital terms such as "internet," "network," and "email," as documented in study papers PS10 to PS22. During this period, IT significantly impacted various businesses with critical innovations, including the widespread adoption of broadband internet connectivity (Majumdar et al., 2010). The prominence of "internet" and "information" in the word counts for phase 2 underscores the theme "Connectivity & Information Revolution."

The internet connectivity surge profoundly impacted the retail sector, mainly through the emergence of e-commerce. This period is epitomized by Amazon's exponential growth from a simple online bookstore into a global retail powerhouse. Integrated IT systems set new standards for retail efficiency and customer interaction by enabling real-time inventory management, personalized marketing, and streamlined logistics. These IT innovations drove the transformation, expanding market reach and elevating consumer expectations for service delivery (Kowal & Paliwoda-Pękosz, 2017).

Phase 3 - Emerging Industry IT

Building on the advancements of the previous phases, the third phase, "Emerging Industry IT," began in 2010 and continues to the present. During this phase, the prominence of specific terminology within the industry has markedly risen, with "data" emerging as the most frequently cited term, as documented in study papers PS23 to PS110. This era is characterized by the widespread adoption of Big Data and Internet of Things (IoT) technologies, which enable businesses to collect and analyze large amounts of data in real-time (Sen & Jayawardena, 2019). Data is now considered a crucial asset for industry growth (Read et al., 2019), leading to the development of new data-driven business models and the rise of data analytics as an essential competency across various sectors (Rakishev, 2023). For example, China's e-commerce industry leverages data to personalize customer experiences, exemplifying the significant impact of data utilization (Saad et al., 2023). Another significant trend is the increasing use of digital technologies in industry, from software development to industrial operations. These technologies enhance efficiency and quality while creating new opportunities.

Artificial intelligence (AI) and machine learning (ML) have become integral to improving decision-making processes. AI algorithms, particularly predictive analytics, are used extensively in healthcare to forecast patient outcomes, enhance diagnostic accuracy, and optimize treatment plans. For instance, predictive models personalize cancer treatment in oncology, improving patient survival rates and reducing side effects (Khanan et al., 2019). Implementing these advanced technologies signifies a critical shift towards data-driven, personalized medicine, reflecting the profound impact of IT on healthcare delivery and patient management. The integration of AI also raises concerns regarding data security, privacy, and the potential for job displacement due to widespread automation in the industry (Khanan et al., 2019). These challenges underscore the need to carefully consider and manage the ethical implications of AI and digital technologies.

Having outlined the key phases and technological advancements, the next section will discuss the broader implications of these developments and the evolving demands for IT skills in the industry.

Evolution of IT in a Broader Context

The evolution of information technology (IT) is significantly reshaping industries across the globe, with its impact manifesting variably across different geographical areas. This underscores the necessity of adopting a global perspective. For instance, initiatives like Singapore's Smart Nation and Japan's Society 5.0 are prime examples of how IT can be strategically integrated with urban development in the Asia-Pacific region. These initiatives establish global benchmarks for intelligent infrastructure, highlighting the region's leadership in harmonizing technology with progressive urban

planning (Brink et al., 2022). In Europe, the regulatory framework, specifically the General Data Protection Regulation (GDPR), has necessitated significant transformations in IT operations, thereby influencing global data management practices (Hindle, 2020). Concurrently, Africa has experienced a remarkable surge in mobile technology utilization, epitomized by the extensive adoption of mobile banking platforms such as M-Pesa. This development has revolutionized financial inclusion and markedly transformed service delivery within healthcare and other sectors (Osabutey & Jackson, 2024).

Examining the evolution of IT reveals distinct impacts across various sectors. For instance, the integration of AI in healthcare has significantly advanced personalized medicine in North America, while in Europe, the focus has been on enhancing manufacturing processes through automation technologies (Sussman et al., 2022). Although IT has driven positive transformations, some scholars argue that the rapid pace of technological change can lead to significant disruptions in labor markets and exacerbate inequalities within industries. These perspectives suggest that the benefits of IT evolution are not universally experienced, with disparities in technology access and impact across different regions and sectors (Freeman et al., 2020). Furthermore, despite the seamless integration of digital technologies, many industries face substantial barriers to fully harnessing these technologies due to legacy systems and organizational resistance (Brink et al., 2022).

The three phases of IT evolution require new skills and knowledge, highlighting a gap between educational program outcomes and industry needs. Understanding the evolution of Information Technology in the industry enhances our comprehension of how evolving IT influences the nature of IT jobs and skills. For instance, programs focusing on data science and AI are crucial in the US due to high demand in tech hubs like Silicon Valley. In contrast, developing economies like India require software development and IT services skills to support their growing tech industries. Additionally, it presents a historical view that shows how the development of IT led to new applications to satisfy changing needs and shape the direction of the industry's evolution. This knowledge is crucial for developing strategies and policies that support entrepreneurship, education and training alignment, technical innovation, economic growth, and job creation in line with the changing IT landscape. For example, in China, government policies have been instrumental in fostering the growth of AI and big data technologies, leading to substantial economic benefits (Păvăloaia & Necula, 2023). Identifying the pattern of change in required IT skills following technological advances suggests essential implications for university education and curriculum development.

LIMITATION

This study is subject to certain limitations. First, the constraints associated with the data collection and analysis methodologies must be acknowledged. These methodologies may influence the comprehensiveness and accuracy of the findings, potentially affecting the generalizability and applicability of the results. Because the scope of this work is broad, the authors used generic phrases (e.g., information technology in industry) rather than keywords for specific technologies. Further limitations include selecting 110 articles from ACM Digital Library, IEEE Xplore, and Google Scholar databases. The databases are reasonable but not all-inclusive of publications related to the evolution of information technology in the industry. This suggests that the final corpus of knowledge may have excluded important literature. Secondly, out of 110 articles, 61.8% were focused on the research question, indicating that the search produced 32.8 % less focused articles. The authors independently applied the quality assurance criteria and conducted the thematic analysis. While this approach mitigates potential biases introduced during quality assessment, it may not significantly reduce biases introduced through thematic analysis. Lastly, the authors narrowed the search using a set of inclusion-exclusion criteria, implying that book chapters, non-peer-reviewed papers, and non-English publications were not included in the final corpus of knowledge. Despite the limitations of the search strategy, the methodological rigor employed and the inclusion of substitute keywords in title and abstract searches suggest that the possibility of an excluded manuscript significantly impacting the analysis and interpretation of the findings is minimized.

RECOMMENDATIONS

To navigate the complexities introduced by IT evolution, policymakers and industry leaders must tailor their strategies according to specific needs and opportunities identified within their sectors. For instance, policymakers could formulate policies that foster innovation in AI and automation, while industry leaders could invest in training programs to upskill employees to handle new technological interfaces. These recommendations aim to maximize the benefits of IT advancements while mitigating associated risks.

In conclusion, the evolution of Information Technology (IT) within the industry has progressed through three distinct phases, each characterized by significant technological advancements and shifts in industry practices. These phases highlight the dynamic nature of IT evolution and its profound impact on industry practices, workforce requirements, and technological advancements. Understanding these phases provides valuable insights for developing strategies to address the evolving needs of IT jobs and skills. It also offers implications for curriculum development and higher education to better align with industry demands.

Future research could significantly expand upon this study by undertaking longitudinal investigations to monitor the ongoing evolution of information technology (IT) and provide deeper insights into emergent trends such as quantum computing and blockchain. Comparative analyses across various sectors are crucial, as they could identify specific challenges and opportunities unique to different industries. Moreover, in-depth examinations of individual industries would enhance our understanding of sector-specific IT evolution, exemplified by cybersecurity studies in finance or IT-enhanced customer experiences in retail.

Impact assessment studies are vital for comprehending how different IT phases affect organizational strategy, worker dynamics, and structural configurations. Additionally, exploring the implications of IT evolution for policymaking and education could contribute substantially to curriculum development and promote equitable technology adoption. Research focusing on IT development in emerging economies, where developmental trajectories often diverge from those observed in developed countries, can offer valuable insights.

Pursuing these research directions would not only advance our knowledge of IT evolution and industry dynamics but also inspire ongoing scholarly discourse, inform practice, and influence policy across global contexts.

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APPENDICES

APPENDIX A: FULL LIST OF ARTICLES

ID	Principal study article title
PS 1	Cross-impact simulation of an emerging industry: The case of data processing
PS 2	Technological trends towards global competition
PS 3	The Soviet computer industry: A tale of two sectors
PS 4	Trends in the computer industry: Life-long subscriptions, magical cures, and profits along the information highway (invited talk)
PS 5	The role of information-communication technology in a new organizational design
PS 6	Computer networking industry technologies: trends and challenges in the Mexican market
PS 7	An MIS course integrating information technology and organizational issues
PS 8	Knowledge worker constraints in the productive use of information technology
PS 9	Information technology and organizational change
PS 10	Roadmap for successful information technology transfer for small businesses
PS 11	Centralizing information technology in a distributed system (again?)
PS 12	The impact of the internet on organizational culture within the IT industry
PS 13	Key trends in the information and communication technologies
PS 14	E-commerce application in the electric utility industry of China
PS 15	Trends in collaborative technologies for supporting knowledge management
PS 16	The information technology era of the vehicular industry
PS 17	Information Technology (IT) industry trends and adaptation of Capability Maturity Model Integration (CMMI) practices in Pakistan
PS 18	An agent-oriented data mining framework for mass customization in the automotive industry
PS 19	New trends in information integration
PS 20	Next generation of transportation and information technologies
PS 21	A stochastic model using self-organization to explore the ICT industry evolution
PS 22	Research on innovation ecosystem in IT industry
PS 23	Business continuity and the banking industry
PS 24	E-business adoption and implications in the banking industry in India
PS 25	Technology trends and industry innovation
PS 26	Challenges of using mobile devices in process industry
PS 27	The changing face of information technology
PS 28	The role of information technology in the development of rural tourism and its presentation

ID	Principal study article title
PS 29	Trends in information and communication technologies for construction: Past, present and future
PS 30	Study on emergence of e-commerce in MICE industry
PS 31	Bridging the research-industry gap: The case for domain modeling
PS 32	A social networking strategy for improving knowledge management and communication in the travel industry
PS 33	Enhancing marine industry risk management through semantic reconciliation of underwater IoT data streams
PS 34	Barriers to adoption of information technology in healthcare
PS 35	Review of trends on ICT convergence in electric industry
PS 36	Industry-Academia Panel: Transforming healthcare with IT
PS 37	Development processes and practices in a small but growing software industry
PS 38	Research and innovative design of search engine for banking industry decision-makers
PS 39	High performance computing and industry 4.0: Experiences from the DISRUPT Project
PS 40	Tracing the evolving trends in electronic skin (e-Skin) technology using growth curve and technology position-based patent bibliometrics
PS 41	Software testing practices in IT industry of Pakistan
PS 42	Transforming the supply-chain management and industry logistics with blockchain smart contracts
PS 43	The growth and evolution of India's software industry
PS 44	Research and implementation of BDaaS cloud platform for security industry
PS 45	Data analytics and BI framework based on collective intelligence and the Industry 4.0
PS 46	Machines learning trends, perspectives and prospects in education sector
PS 47	A design approach towards affording the trend of privacy
PS 48	A research on SOA in the IT industry of Pakistan
PS 49	World trends of modern information and telecommunication technologies development
PS 50	Technological trends in context of Industry 4.0 and their industrial applications
PS 51	Big data: Evaluation of the basic trends of the Russian market
PS 52	Attitude of international tourist towards ICT and digital services in tourism industry of Nepal
PS 53	Practices and challenges of using think-aloud protocols in industry: An international survey
PS 54	Research on artificial intelligence for the development of fashion industry
PS 55	The emerging AI policy for e-commerce industry
PS 56	Application analysis of big data technology in feeding industry
PS 57	Research on the current situation and future trend of web celebrity e-commerce live streaming industry
PS 58	Research on the development trend of civil aviation informatization technology based on patent big data analysis
PS 59	The impact of internet development on the development of commercial circulation industry
PS 60	Analyzing the trends in the digital economy and the factors of industrial clustering
PS 61	Monitoring maritime industry 4.0 systems through VR environments
PS 62	Analysis of the coupling coordination relationship between digitalization and cultural industry
PS 63	Features of fuel and energy complex management under digitalization and implementation of industry
PS 64	Research on the influence of AI on Chinese hotel industry

ID	Principal study article title
PS 65	A method proposal for conducting simulation projects in Industry 4.0: A cyber-physical system in an aeronautical industry
PS 66	Impacts of Industry 4.0 on operations management: Challenges for operations strategy
PS 67	Research on the development status of internet literature industry based on co-word cluster analysis
PS 68	Research on application of information management technology in computer big data system
PS 69	The impact of Industry 4.0 technologies on retail development
PS 70	Skills gaps in the industry: Opinions of embedded software practitioners
PS 71	Digital transformation in the Russian industry: Key aspects, prospects and trends
PS 72	Application of electronic information technology in industrial automation industry chain
PS 73	Research on 5G based artificial intelligence technology and its development trend
PS 74	Overview of industrial internet technology development and evolution
PS 75	Application and exploration of digital construction and information technology in the construction of civil architecture specialty group in higher vocational colleges
PS 76	Identifying technology trends for blockchain applications in Industry 4.0 domain: A patent perspective
PS 77	Transformation of business technologies into digital platforms and evaluation of the effectiveness of their application
PS 78	An impact of digital technology on education industry for innovative practices of teaching and learning process: Emerging needs and challenges
PS 79	The role of Internet in the transformation and development of equipment manufacturing industry: The case of Henan Province
PS 80	Research on digital transformation in cultural and creative industries to realize Industry 4.0
PS 81	Information system establishment of average fuel consumption and electric vehicle in China by big data technology
PS 82	Digitalization of the garment industry: Assessment of economic efficiency
PS 83	Application of digital information technology to the quality management system of power grid engineering
PS 84	An analysis of hot topics and trends in foreign 3D printing technology research analysis of knowledge graphs based on citation indexes such as SSCI
PS 85	Analysis of software engineering skills gap in the industry
PS 86	The impact of artificial intelligence and data fusion technology on the accounting industry and its countermeasures
PS 87	Applications and future of dense retrieval in industry
PS 88	The new generation of information technology development drives the servitization of China's manufacturing industry
PS 89	Research progress and trend prospect of blockchain technology application in logistics and supply chain information system under pandemic-hit
PS 90	Technology trends and characteristics of patent information disclosure in advanced semiconductor photoresist
PS 91	Blockchain technology evolution trends bibliometrics analysis on Scopus database using VOSviewer
PS 92	Trends in industrial networks including APL, TSN, WiFi-6E and 5G technologies
PS 93	Factors that influence MSMEs to adopt technology-based accounting information systems
PS 94	The core industry manufacturing process of electronics assembly based on smart manufacturing
PS 95	A systematic review of data quality in CPS and IoT for Industry 4.0
PS 96	Poster: Handling inconsistent data in Industry 4.0

ID	Principal study article title
PS 97	A taxonomy of information attributes for test case prioritization: Applicability, machine learning
PS 98	Tourism 4.0: Opportunities for applying industry 4.0 technologies in tourism
PS 99	Research on application of big data technology based on SVAR model in the development of trust industry
PS 100	The coupling effect between digital economy and urban leisure industry: A time variation based quantitative analysis
PS 101	Emerging trends of ICT in airborne disease prevention
PS 102	Evolving roles and implications of technology enabled by 5G in various industries
PS 103	Conceptual modeling: Topics, Themes, and technology trends
PS 104	Professional development of IT industry specialists at the workplace: Trends, focus and prospects
PS 105	Forecasting IT industry trends using a fuzzy decision support system
PS 106	Global trends of IOT in pharmaceutical industry: A bibliometric analysis of Scopus database
PS 107	Trends of digital transformation in the property management industry: A systematic literature review
PS 108	The role of Internet of Things in developing competitive healthcare devices: A case study in the digital healthcare industry
PS 109	Evolution and trends of cloud on industrial OT networks
PS 110	The rising trends of smart e-commerce logistics

APPENDIX B: CODED WORDS AND THEIR DEFINITIONS

Word	Definitions
Management	Coordination and utilization of resources
Information	Knowledge and insight
System	Interconnected components
Technology	Tools and systems
Technology	Technology raw information
Organization	Structure and culture
Issues	Challenges and constraints
Computer	Hardware and software
Business	Commercial and industrial activities
Constraint	Limitations and restrictions
Student	Individuals in studies
Support	Assistance and guidance
Worker	Individual in knowledge work
Technical	Relating to technology
Change	Modifications and adaptions
Solution	Proposed actions and strategies
Design	planning and structuring systems
Productivity	Efficiency and effectiveness
Time	Aspect of influencing knowledge
Simulation	Method or tools

Word	Definitions
Research	Systematic investigation
Information	Processed data
Internet	Global network
Data	Raw facts
Business	Commercial activity
Industry	Sector of economic activity
innovation	Create and implement new ideas
Integration	Combine different elements
Network	System of interconnected things
Technology	Apply science knowledge for practical's
Organization	People working together
ICT	Use of digital technology for communication
Electric	Use of electricity for devices
System	Interconnected component working
Knowledge	Process or organized information
System	System digital communication for messages
Support	Assistance or help
Systems	Set of interconnected components
Based	Founded or built upon
Research	Systematic investigation
Time	Period or duration
Culture	Shared belief or values
Access	To obtain or use
Management	Planning organizing & controlling
Employee	Individual hired
User	Individual or organization
Commerce	Exchange of goods and services
Software	Computer program or application
Firms	Business or company
Processes	Series of steps
Power	Capacity to do something
Ecosystem	Complex system of living organism
Development	Process or creating
Rule	Principle or guidelines
Data	Raw information
Industry	Landscape of industrial automation
Information	Data generated and use
Technology	Tools techniques and methods
Development	Process of creating
Research	Systematic investigation

Word	Definitions
Software	Application or program
Digital	Use of digital tools
System	Architecture of industrial automation
Analysis	Process or examining
Management	Coordination of industry automation

APPENDIX C: SOURCE CODE

…….
Phase 1 (Advent of Industry IT)
.....

```
# Specify the path to your PDF file
pdf _ file <- "C:/ Thematic /pdf /1. pdf "

# Extract text from the PDF
pdf _ text <- pdf_ text ( pdf_ file )

# Create a data frame from the PDF text
data1 <- tibble ( Text = pdf _ text )

# Tokenize the text
words <- data1 %>%
unnest _ tokens ( output = word , input = Text )

# Define custom stop words ( words to be excluded from analysis because it is noise )
custom _ stop _ words <- c("pp", "1", "2", "3", "4", "5", "6")

# Filter out common stop words and custom stop words
words <- words %>%
anti _ join ( stop _ words ) %>%
anti _ join ( data _ frame ( word = custom _ stop _ words ))

# Count the words
wordcounts <- words %>%
count (word , sort = TRUE )


# Create a bar plot of the most frequent words (e.g., top 15 words )
wordcounts %>%
filter (n >= 50) %>%
mutate ( word = reorder (word , n)) %>%
ggplot (aes (word , n)) +
geom _col () +
coord _ flip () +
labs (x = " Words ", y = " Count ") +
```

```
geom _ text (aes ( label = n), hjust = 1.2 , color = " white ", fontface = " bold ") +
theme (
plot . title = element _ text ( hjust = 0.5) ,
axis . title .x = element _ text ( face = " bold ", color = " red ", size = 10) ,
axis . title .y = element _ text ( face = " bold ", color = " red ", size = 10)
)
```

.....

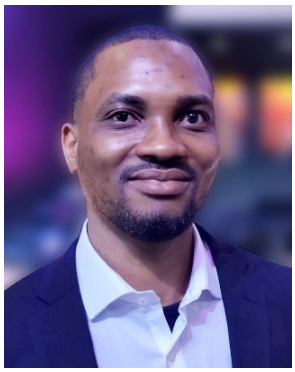
Phase 2 (Connectivity & Information Revolution)

.....

```
# Specify the path to your PDF file
pdf _ file <- "C:/ Thematic / pdf/2. pdf "

# Extract text from the PDF
pdf _ text <- pdf_ text (pdf_ file )

# Create a data frame from the PDF text
data1 <- tibble (Text = pdf _ text )

# Tokenize the text
words <- data1 %>%
unnest _ tokens (output = word , input = Text )

# Define custom stop words (words to be excluded from analysis because it is noise)
custom _ stop _ words <- c ("pp", "1", "2", "3", "4", "5", "6")

# Filter out common stop words and custom stop words
words <- words %>%
anti _ join ( stop _ words ) %>%
anti _ join ( data _ frame ( word = custom _ stop _ words ))
Joining with `by = join _by( word )`
Joining with `by = join _by( word )`

# Count the words
wordcounts <- words %>%

count (word , sort = TRUE )

# Create a bar plot of the most frequent words (e.g., top 15 words )
wordcounts %>%
filter (n >= 60) %>%
mutate ( word = reorder (word , n)) %>%
ggplot ( aes(word , n)) +
geom _ col () +
coord _ flip () +
labs (x = " Words ", y = " Count ") +
geom _ text ( aes( label = n), hjust = 1.2 , color = " white ", fontface = " bold ") +
theme (
plot . title = element _ text ( hjust = 0.5) ,
```

```
axis . title .x = element _ text ( face = " bold ", color = " red ", size = 10) ,
axis . title .y = element _ text ( face = " bold ", color = " red ", size = 10)
)

.....
Phase 3 (Emerging industry IT)
.....
# Specify the path to your PDF file
pdf _ file <- "C:/ Thematic / pdf/3. pdf "

# Extract text from the PDF
pdf _ text <- pdf _ text ( pdf_ file )

# Create a data frame from the PDF text
data1 <- tibble ( Text = pdf _ text )

# Tokenize the text
words <- data1 %>%
unnest _ tokens ( output = word , input = Text )

# Define custom stop words ( words to be excluded from analysis because it is noise )
custom _ stop _ words <- c("pp"," 2020 ", "7", "1", "2", "3", "4", "5", "6")

# Filter out common stop words and custom stop words
words <- words %>%
anti _ join ( stop _ words ) %>%
anti _ join ( data _ frame ( word = custom _ stop _ words ))

# Count the words

wordcounts <- words %>%
count (word , sort = TRUE )

# Create a bar plot of the most frequent words (e.g., top 15 words )
wordcounts %>%
filter (n >= 600) %>%
mutate ( word = reorder (word , n)) %>%
ggplot ( aes(word , n)) +
geom _ col () +
coord _ flip () +
labs (x = " Words ", y = " Count ") +
geom _ text ( aes( label = n), hjust = 1.2 , color = " white ", fontface = " bold ") +
theme (
plot . title = element _ text ( hjust = 0.5) ,
axis . title .x = element _ text ( face = " bold ", color = " red ", size = 10) ,
axis . title .y = element _ text ( face = " bold ", color = " red ", size = 10)
)
```

AUTHORS



Siddique Abubakr Muntaka is a Graduate Teaching Assistant at the University of Cincinnati, pursuing a Ph.D. in Information Technology focusing on Cyber Security, Cloud, and Networks. Holding a master's degree in IT, his research centers on Anonymity Networks. He applies network science methodologies to enhance cybercrime investigation and cyber attribution for law enforcement agencies. His work merges theoretical cybersecurity foundations with practical solutions, bolstered by over a decade of experience and a dedication to student-centered teaching. Siddique's efforts advance cybersecurity practices and fortify national defenses against cyber threats and warfare.

Joel Appiah is a Graduate Research Assistant at the University of Cincinnati, where he is also pursuing his Ph.D. in Information Technology. His research interests span Cyber Security, the Industrial Internet of Things (IIoT), Systems Administration, and Vulnerability Assessment. He is actively engaged with research projects at the Ohio Cyber Range Institute (OCRI), focusing on advancing cybersecurity measures and strategies in response to evolving digital threats. Joel emphasizes developing and implementing robust security protocols for critical infrastructure and networked systems.

Dr. Hazem Said is a Professor of Information Technology and the director of the School of Information Technology (SoIT) at the University of Cincinnati (UC). He is a certified Project Management Professional (PMP). Dr. Said founded the UC Information Technology Solutions Center (ITSC) in 2012, where he consults with government, public and private organizations, and leads teams of professionals, as well as graduate, undergraduate, and high school students, to investigate, develop, and support a variety of information technology solutions. In addition, Dr. Said is a co-founder and co-director of the Ohio Cyber Range Institute and the Justice, Law, and Information Technology Institute. Dr. Said is the recipient of over 200 grants and contracts totaling over $30 million and has authored over 30 articles on topics related to information technology education.