Digitalization of Training and Development: A Bibliometric Analysis

*Malabika Sahoo[1] and Sumita Mishra[2]

[1] KIIT School of Management, KIIT Deemed to be University, Bhubaneswar, India
Malabika.sahoo@ksom.ac.in,
[2] KIIT School of Management, KIIT Deemed to be University, Bhubaneswar, India

Abstract

In the current scenario, the rapid use of digital technologies has profoundly reshaped different functions of organizations. Digitalization has transformed the landscape of training and development (T&D), introducing new approaches to training delivery, design, and flexible learning. The use of AI and VR also facilitated significant transformations in the training and development system. Despite the widespread adoption, the organization still faces paramount challenges for a digitalized training system. A comprehensive understanding of the research landscape on digitalization of training and development and identification of promising future research directions remains crucial. Through a bibliometric analysis of the existing literature on digitalization of training and development, this study provides a structured overview of the field's evolution through analysis of publication trends, key themes, influential authors and journals, and emerging research areas using quantitative and bibliometric coupling techniques. Furthermore, based on the findings, we propose a future research agenda, highlighting critical areas for investigation to advance the understanding and practice of digitalized T&D.

Keywords: Digitalization, Digitalized training, Training and development, Bibliometric analysis.

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1 Introduction

In the era of Industry 4.0, the emergence of digital technology has considerably influenced different industries, work processes and functions, with training and development (T&D) being no exception (Hulla et al., 2019). T&D plays a critical role in escalating the knowledge, skills, and abilities (KSAs) of the employees (Sahoo & Mishra, 2018, 2022). Digitalization of Training, usually referred to as e-learning or online learning, has transformed the way employees gain KSAs and is matched to the demands of the modern workplace. Online learning, or e-learning, proved to be a powerful driver of change and development. It has transformed the way individuals learn, upskill, and meet the requirements of a competitive work environment. The shift to digital learning and training has been influenced by factors such as easy access to technology, flexible learning approach, and rising cost of traditional training methods (Veres et al., 2021; Barykin et al., 2020).

The traditional T&D approaches, such as in-person training programmes, learning workshops, lectures, and physical materials, often have limitations in addressing the diverse needs of organizations and employees (Mosier, 1990; Benson-Armer & Dam, 2015). Digitalization of T&D system is considered as an alternative, extending accessible, flexible, and cost-effective learning solutions. (Sarker et al., 2019). In the current scenarios, e-learning platforms, online courses, virtual reality simulation, artificial intelligence, and mobile learning applications are more prevalent and offer learners the opportunity to gain the required KSAs at their own pace, time, and space (Kumar et al. 2019).

The digitalization of T&D extends lots of benefits for both employees and organizations (Simon,2023). Digitalized training allows the trainees greater flexibility, better access to training materials, to participate in learning activities at their convenience, and eliminates the time and location constraints (Shamim et al., 2021). More importantly, digital learning environments can be customised to match individual learning styles and preferences, which boosts learner engagement and retention of KSAs (Maria et al.,2019). Furthermore, digitalization helps in cost management and

allows for delivering training programs more efficiently, reducing physical material costs, logistic arrangements, and travel expenses. (Rai and Lata 2024.)

However, the transition from traditional mode to digital form also has many challenges. Firstly, it is really difficult to ensure the active engagement of trainees in the learning process. An online training environment can be effective through innovative curriculum design and interactive learning activities (Koutsoupidou, 2015). Secondly, organizations usually face the challenges of addressing the digital divide and providing equitable access to the internet and technology for all learners (Rasheed et al., 2020). Furthermore, evaluating the effectiveness of the digital training is difficult (Benson-Armer & Dam, 2015). Thus, in spite of the extensive adoption of digitalization of T&D, there is a research call for a comprehensive understanding of its impact, effectiveness, and future trajectory. This study aims to address this need by examining the extant literature on the digitalization of training and development.

In this study, we have used bibliometric analysis to examine the research trend of digitalization of training and its impact. We have done a systematic review of extant literature to track its evolution and identify emerging themes utilising a transparent and structured analytical approach. Through this study, we offer several important contributions to the field of T&D. First, we offer a comprehensive and structured overview of the extant literature on the digitalization of T&D through a summarization of key findings. Second, through this review, we identify emergent trends and suggest future research directions, guiding future research efforts. Third, we extend managerial implications for organizations for the effective use of digital training strategies. Finally, we contribute to the scholarly discussion on the future of work and learning, giving emphasis on the role of digitalization in shaping future workforce KSAs.

We used bibliometric techniques such as citation analysis, co-citation, and keyword analysis to examine the research landscape.

The broad objectives of the study are

1. To visualize the growth and advancement of research on the Digitalization of T&D over time.
2. To determine the prominent themes and trends within the literature on the digitalization of T&D
3. To identify the most impactful journals, authors in the field.
4. To propose a future research agenda on the digitalization of T&D

The paper is structured as follows: Section 2 outlines the research approach, while Section 3 presents the findings from the bibliometric analysis. Section 4 discusses key implications for both theory and practice. Finally, Section 5 highlights the study's limitations and proposes a future research agenda.

2. Methodology

Bibliometric analysis is a powerful method to examine the evolution and trends in a specific field of study. This approach through quantitative analysis extends valuable insights, highlighting key themes and emerging trends (Ananda et al.,2021).

2.1 Search Strategy and Data Collection

We used the Web of Science database to capture data for this research. We employed a systematic approach using the keywords such as "training digitalization" or "Digitalized training" or "staff training digitalization" or "digitalized learning and development" or "e staff training" or "technology in training".

2.2 Inclusion and Exclusion Criteria

2.3 Data Analysis

The 146 selected articles were analyzed using software tools like VOSviewer and R studio to identify citation patterns, co-authorship networks, and thematic clusters. Quantitative analysis, including the identification of leading journals, author affiliations by country, top-cited authors, annual research output, and word cloud visualization, was conducted using R studio. Additionally, relational analysis, specifically bibliometric coupling, was performed using VOSviewer (Priovashini & Mallick, 2022).

3. Results

3.1 Annual Production Over Year

The annual production of research papers has shown a fluctuating trend over the years. A significant peak in article production was observed in 2013, indicating heightened interest or a major development in the field of digitalization in training during that period. A sharp decline occurred after 2013, with the number of articles decreasing significantly by 2017. This downward trend continued, reaching a low point in 2021. After 2021, there was a noticeable recovery, with the number of publications increasing sharply through 2023. This suggests a renewed interest in the topic, possibly driven by technological advancements or the global shift to digital platforms during and after the COVID-19 pandemic. The data reflect that the field of digitalization in training has experienced periods of both high and low research activity. The recent surge indicates growing attention to the topic, potentially due to emerging technologies like AI, VR, and gamification in training methods.

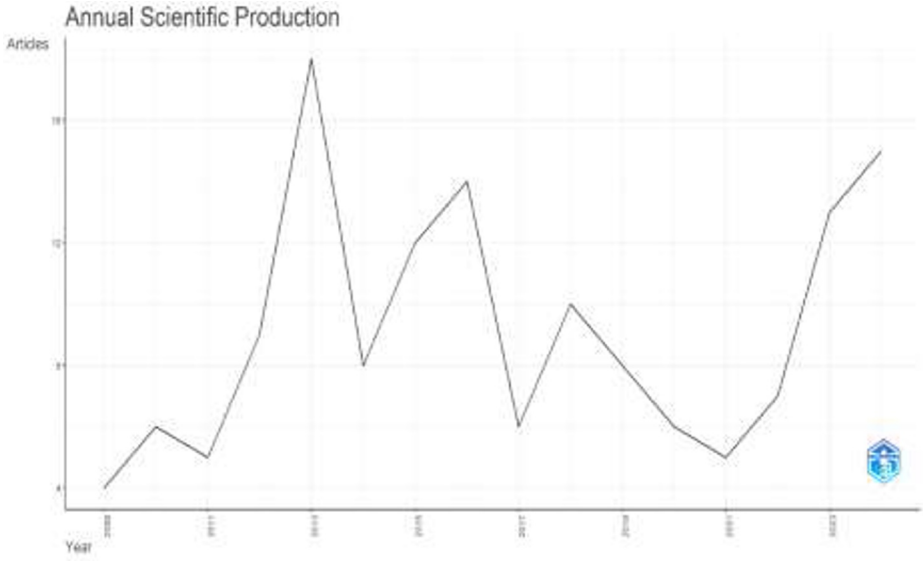

Fig 1. Publication trend over the years from 2009 to 2024

3.1.1 Most prolific authors

Table 1. Prominent Authors

Authors	Articles
Avramescu ET	3
Lupescu O	3
Acsinte A	2
Antonopoulos G	2
Balint G	2
Bhatti MA	2
Chircu S	2
Ismail N	2
Niculescu G	2
Palkova Z	2

Table 1 presents the distribution of scholarly contributions by various authors in the field of digitalization of training and development. The bibliometric analysis identifies key contributors based on the number of articles published. Among the listed authors, Avramescu et al. and Lupescu O have the highest number of publications, with three articles each, highlighting their significant contributions to the domain. Other notable authors, including Acsinte A., Antonopoulos G., Balint G., Bhatti MA., Chircu S., Ismail N., Niculescu G., and Palkova Z., have each contributed two articles to the field.

3.1.2 Publication distribution by leading journals

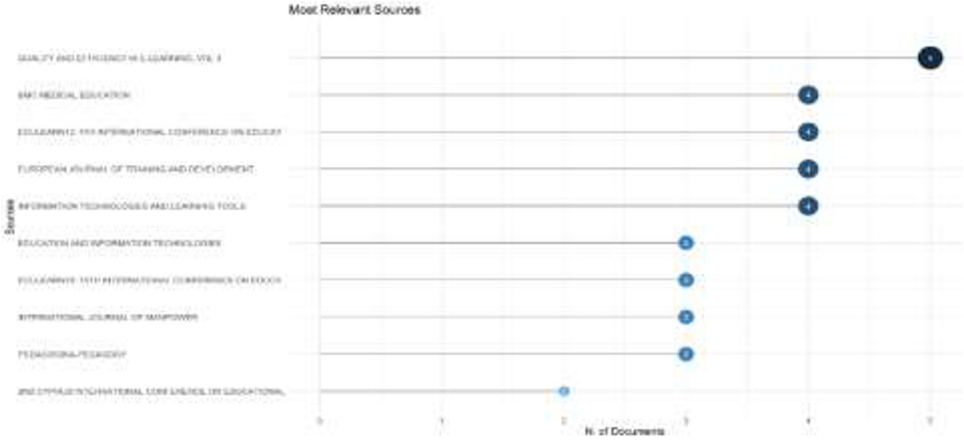

Fig 2. Publication distribution by leading journals

Figure 2 presents the most relevant sources contributing to research in the digitalization of training and development, measured by the number of documents published. "Quality and Efficiency in E-Learning, leads as the most significant source, with 5 documents, indicating its prominent role in this domain. BMC Medical Education, European Journal of Training and Development, and Information Technologies and Learning Tools contributed 4 documents, showcasing their influence in advancing research on digital education and training methodologies.

These sources emphasize themes such as e-learning, information technologies, and pedagogy.

3.1.3 Country-wise publication distribution

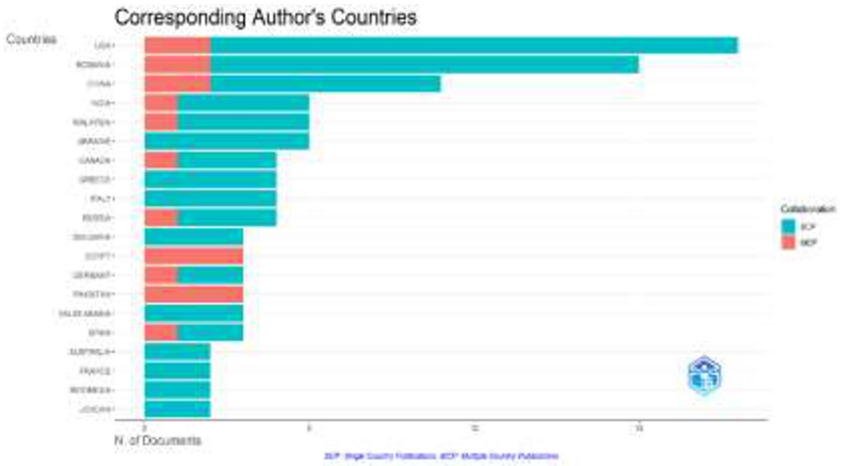

Fig 3. Country-wise publications

Figure 3 highlights the distribution of corresponding authors' countries in research on the digitalization of training and development, segmented into Single Country Publications (SCP) and Multiple Country Publications (MCP). The USA dominates with the highest number of publications, primarily SCP, showcasing its strong independent research output. Romania and China follow, contributing significantly with a balanced mix of SCP and MCP, reflecting active international

collaborations. Other key contributors include India, Malaysia, Ukraine, and Canada, which also display a blend of independent and collaborative research. In contrast, countries like Australia, France, Indonesia, and Jordan exclusively feature SCP, emphasizing domestic research focus. Overall, the chart illustrates the global nature of the field, driven by both independent efforts and international partnerships.

3.2 Bibliometric Relational Analysis

3.2.1 Analysis of Keywords and Textual Analysis

The visualization, created using VOS viewer, showcases the interconnected network of key terms related to research on digitalization in training and development. Central themes such as e-training, e-learning, education, and performance emerge prominently, with surrounding nodes representing closely related concepts. Terms like technology, self-efficacy, satisfaction, and management highlight critical areas of focus, ranging from technological adoption and user acceptance to the outcomes of training programs. The network also emphasizes interdisciplinary connections, linking educational technology and knowledge management to professional development, motivation, and job performance. Clusters of terms reflect diverse research interests, from mobile learning and case studies to the role of ICT and skills development. This interconnected web illustrates the multifaceted nature of digitalization in training, where technological, educational, and performance-oriented aspects converge.

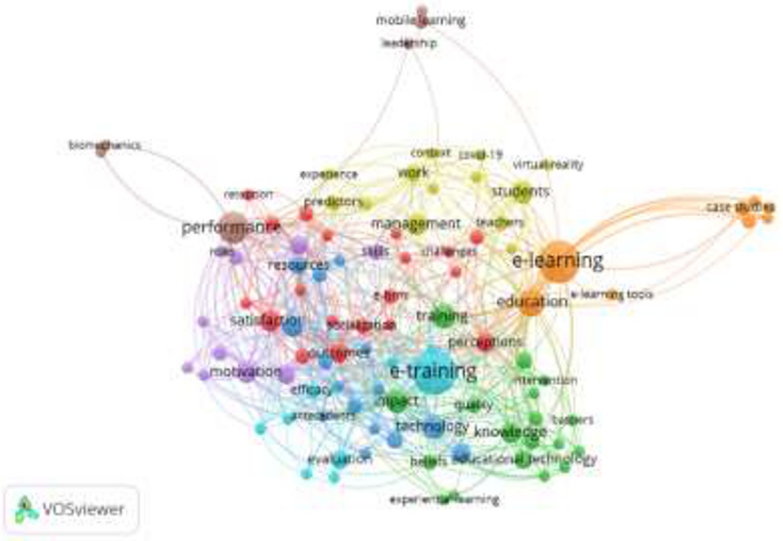

Figure 4. Co-occurrence map of keywords

Figure 4 portrays a cluster visualization of keyword co-occurrence in e-learning research, created using VOSviewer. The clusters represent distinct thematic areas within e-learning research.

- **E learning**: the cluster with e-learning as the prominent keyword marked by orange colour highlights "e-learning," "education," and "case studies," which indicates a core research area on digital education strategies.
- **Knowledge on technology**: The second cluster, marked with green colour, centers on "technology knowledge," "educational technology," and "intervention," highlighting research on the integration of digital tools.
- **E training**: The third cluster (blue colour) highlights "e-training," "evaluation," and "impact," suggesting research training, evaluation, and effectiveness.
- **Performance**: The cluster marked by brown colour relates to "performance," "satisfaction," and "resources," highlighting factors to enhance performance.

3.2.2 Interconnections Between Keywords:

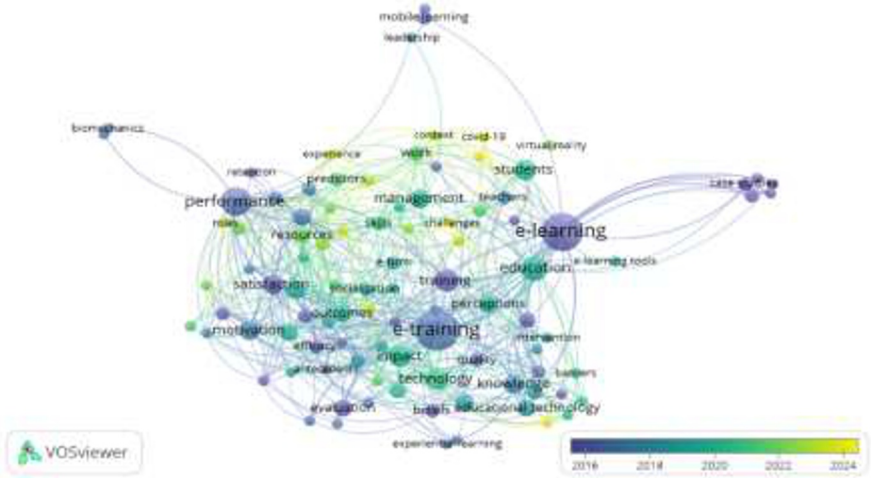

Fig 5. Density Visualization

The overlay density visualization of keyword co-occurrence in e-learning and related fields shows the association between words such as "e-learning," "e-training," "performance," and "education," highlighting their connection. The color gradient, from dark blue (older studies) to yellow (recent studies), indicates the evolution of research trends from 2016 to 2024. Emerging topics like "virtual reality," "COVID-19," and "mobile learning" suggest a growing interest in technology-enhanced education. This visualization provides insights into the dynamic development of e-learning research and its impact on education and training methodologies.

4.Role of AI-driven personalized learning (AIDPL) and Virtual reality (VR) in Training and development

AIDPL in T&D employs artificial intelligence (AI) for creating personalized learning experiences for employees in the organization. Compared to traditional training approaches, AI can analyze trainees' data, such as earlier knowledge, experience, learning style and preferences, career objectives, and performance, and develop customized

training content, a suitable delivery mode to tailor content, delivery methods, and learning plans (Madhumithaa et al., 2025). Virtual reality (VR) extends a dynamic learning environment that imitates real-world situations and provides experiential learning in a controlled and safe environment. This technology goes beyond traditional methods by allowing learners to engage with simulated environments (Holuša et al., 2023).

Given below are varied AI functionalities through which AI and VR can tailor the T&D system

4.1 Customized content: AI algorithms can help the learners through assessing the real-time development and can adjust the format and sequencing of learning. When a trainee faces difficulty in understanding, AI can help through a simpler explanation of the concept and additional reading materials (Tanweer& Ismail, 2024).

4.2 Chatbots and Intelligent Tutoring Systems: AI fosters learning experience through chatbots and virtual assistants offering quick feedback, answering queries, and extending guidance mimicking human tutor responses (Casillo et al., 2020; Huang et al., 2023).

4.3 Competency Mapping: Through analysis of industry trends and performance metrics, AI can be used for competency mapping to identify skill gaps. Based on the skill gaps, AI can suggest personalized training modules to address these deficiencies (Yel, 2025; Sidhu et al., 2024).

4.4 Use of Predictive Analytics: Organizations can use AI to envisage possible challenges faced by trainees and for forecasting future-ready competencies. This will help the organizations to address learning needs in advance and plan workforce development strategically (Ikhsan et al., 2025).

4.5 Gamification and Engagement: AI can be used to personalize gamified learning through the adoption of game scenarios, which in turn can augment trainees' engagement and motivation, leading to joyful learning experiences (Rana & Chicone, 2025). In a training scenario, VR captures the attention of learners more effectively, resulting in better engagement and retention of learning and Skills (Yazdi, 2024).

4.6 Time and Cost management: Though the initial setup cost can be challenging, VR can manage costs in the long run by reducing expenses, the cost of physical training materials, logistic costs, and also lessens overall training time (Maity, 2019)

5.Theoretical contributions

This study offers several theoretical contributions. The study extends a structure to understand the evolution of the field, emerging themes, and avenues for future research. The review mapped the intellectual landscape of digitalization of training and development research and identified core themes and dominant clusters. This contributes to the extant literature by clarifying how different areas are related and in which areas significant contributions have been made. The review traced the evolution of keywords, prominent authors, and journals and identified prominent gaps and under-researched areas within the field of digital training. This will help future scholarly efforts to address these gaps and expand the boundaries of knowledge. The theoretical frameworks that explain the mechanism through which digitalization influences T&D outcome are social cognitive theory (Bandura,2001) and social exchange theory (Blau,1964). Social cognitive theory highlights the importance of self-efficacy for enhancing performance. Digital tools and AI, through extending immediate feedback, help to overcome challenges in learning and can enhance self-efficacy, which leads to motivation, persistence, and skill gain and applications. Social exchange theory suggests that social behaviour is a result of an exchange process. In training, employees exchange their time and effort for perceived benefits. When digitalization of training and AI adoption is considered as valuable and relevant by employees, it leads to a meaningful exchange relationship, leading to satisfaction, engagement in training, and better training outcomes.

6.Managerial Implications

The study findings offer important implications for organizations, training managers, and Practitioners. First, owing to the rapid growth of digitalization in the era of Industry 4.0, organizations should be open to investment in the digitalization of the T&D process and AI-driven learning tools and VR simulations. Managers need to consider these

investments as strategic investments that can escalate organizational performance. Second, the dominant themes and trends outlined in this study will help training and HR managers to design more customised training programmes (Suravi,2024; Simon, 2023). Third, the rapid technological advancement suggests managers adopt emerging technologies, AI, VR, and gamification for enhancing training effectiveness and learners' engagement in the training programmes (Souvik,2019; Upadhyay et al.,2019). Further, the review underscores the relevance of learners' experience in digital training. Managers need to create an engaging and user-friendly learning environment matching diverse learning preferences and learning styles(Sadler-Smith, 1996). Managers must focus on evaluating the effectiveness of digitalized training programmes. They need to assess the effectiveness based on data and feedback. Managers should invest in trainer development, empower them with competencies to use digital technologies (Brunello et al., 2024; Lopeset al., 2023). Furthermore, organizations must address ethical considerations, ensuring privacy of data and addressing potential biases (Bhattacharya et al, 2022).

For the health care sector, digitalization offers immense opportunities to make T&D initiatives more effective. For example, healthcare sectors can use VR simulations for surgical procedures, AI-based diagnostic training, and customised e-learning modules (Rizvi & Zaheer, 2022). For manufacturing sector managers, VR can be adopted for on-the-job training and complex machinery operations, which helps to enhance efficiency and can reduce errors. Employees can upskill using digital learning platforms (Woolf et al., 2020). The retail sector can get immense benefits through digitalized training and the use of AI in training employees. Managers can conduct sales and product knowledge training through digital mode, covering a large target audience. Managers in the retail sector can foster continuous learning opportunities through AI adoption in training (Brough, 2025).

7. Future Research Agendas

The review offers a future research agenda for researchers to explore the topic in depth.

7.1 Exploration of Core Themes

Future researchers should explore and examine themes like e-learning, e-training, and technology adoption. Though these themes are dominant in literature, the use of technology, AI-based customised learning remains underexplored.

7.2 Bridging Performance and Digital Training

The network analysis highlights *performance* as a key concept. Future studies should explore how digital training interventions directly impact employee productivity, engagement, and long-term skill retention. There is a need for empirical validation of digital training's effectiveness across industries.

7.3 Emerging Technologies and Their Role in Digital Training

Research should focus on virtual reality, augmented reality, gamification, and AI-powered learning assistants in training and development. These technologies are underrepresented in existing literature but have significant potential to enhance learning experiences.

7.4 Sustainability and Ethical Considerations in Digital Training

There is limited research on the sustainability and ethical aspects of digital training. Future studies should explore issues like digital fatigue, privacy concerns in AI-driven training, and sustainable e-learning practices to ensure responsible digital training adoption.

7.5 Longitudinal Studies on Digital Training Evolution

There is a lack of longitudinal research tracking the evolution of digital training over time. Future research should analyze trends in *e-training* adoption, technological innovations, and evolving learner expectations to predict future shifts in training methodologies.

8. Study Limitations

This bibliometric analysis, while offering valuable insights into digitalization in training and development, has limitations. We used Web of Science as the lone

database, which may limit the generalizability of the study. Publication bias favors published works, potentially overlooking other scholarly output.

9. Conclusion

This bibliometric review provides a comprehensive understanding of the digitalization of training, offering valuable insights for academics, practitioners, and policymakers. By examining publication trends, key themes, influential authors and journals, and emerging research areas, this study has offered valuable insights into the evolution and current state of the field. The findings highlight the growing interest in digitalized T&D, as evidenced by the increasing number of publications over time. Future research should explore the long-term impact of digital training on workforce development, investigate cross-cultural implications, and examine ethical considerations related to AI-driven training tools.

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By understanding the evolving research landscape, T&D professionals can make informed decisions to maximize the effectiveness and impact of their initiatives.

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