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Digital transformation and human capital: A bibliometric analysis

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Abstract
This research paper presents a bibliometric analysis focused on exploration of the potential applications of digital transformation in human resource management. The primary objective is to identify and examine the key characteristics of this field, current research trends, their progression and potential research gaps that can be explored in future studies. To acquire pertinent publications for the purpose of analysis, a thorough compilation is assembled from widely recognized scientific databases through specific search queries. This is then followed by the removal of any incorrect entries. The analysis encompasses trend analysis, co-occurrence analysis, and citation analysis. The conclusions drawn are graphically displayed with charts and tables. To performed bibliometric analysis, we used "VOS viewer". The literature review provides insights into the latest perspectives on digital transformation. Moreover, the conclusions drawn from the analysis are expanded upon to propose potential future research extensions and offer suggestions for stakeholders involved in this domain.

Keywords: Information systems management, innovation, organizational development, organizational performance, technology science, tertiary education

1. Introduction

If machines, whether acting automatically or with foresight (robots), were able to perform their tasks (.), then the masters would have no need for slaves."

-Aristotle (Politics, 1253.6.35)

The Bibliometric analysis, also known as 'Statistical Bibliography', has its epistemological roots in bibliography and constitutes a factor of quantitative and qualitative measurement in assessing information sources [1].

The term 'Bibliometrics' was proposed by Alan Pritchard [2] in 1969. In the definition he provided, 'Bibliometrics' refers to the 'quantitative analysis of bibliographic references as they appear in bibliographies, with the aim of developing evolutionary models for science and technology. Bibliometric analysis of references is made possible by utilizing tools such as the Web of Science platform, Scopus, Google Scholar, and similar databases.

Bibliometrics works in conjunction with Information Sources to pinpoint gaps within bibliographic collections, uphold their authenticity, and allow for corrections and the periodic elimination of outdated information.

Furthermore, the bibliometric analysis is based on the descriptive fields of the original documents, as formulated by the document analysis domain, including practices like cataloging and classification, among others.

In situations where locating a specific document becomes challenging due to the high volume of data, the solution lies in bibliographic and information sources, whether in printed or digital form. This is crucial for obtaining the necessary documents, whether for analyzing a particular subject matter or for identifying and acknowledging researchers involved in it. The application of this approach encompasses extracting essential information and appropriately quantifying data, measuring using suitable methods, calculating constraints by comparing data, and presenting and interpreting bibliometric indicators through the creation of charts and maps [3].

The present paper demonstrates a bibliometric analysis of the research literature on potential

applications of digital transformation in human resources, aiming to the identification of the main characteristics of this research field, current research trends and its evolution, as well as gaps in the literature for future research.

The compilation of publications being examined was sourced from the leading academic databases, namely Scopus and Web of Science. Various types of analysis were conducted, and the results are presented through graphs and tables. Additionally, discussions take place regarding the extraction of valuable conclusions and the formulation of proposals for future research. The aim of the present study is the bibliometric analysis of digital transformation in human resources management.

The current study represents an initial systematic endeavor to examine the influence of digital transformation on human resources management using bibliometric techniques.

The primary motivation of the authors is to highlight the correlation between digital transformation and human resources management, underscore the significance of digital transformation in human resources management, and identify emerging trends and opportunities for research and future expansion in this specific domain.

Furthermore, it can offer a comprehensive overview and an analytical method for the researchers in this specific field.

Through the bibliometric analysis, the present study aims to address the following questions:

- What are the emerging trends in the application of digital transformation in the field of human resources?
- What are the most popular research areas concerning digital transformation and human resources management?
- How many times is each study cited by other studies, and which studies have the highest number of citations?
- What are the most commonly used search terms related to digital transformation and human resources management?

The remainder of this paper is structured as follows. In Section 2, we examine the impact of digital transformation on human resources management and the utilization of information systems, which has ushered in a new trend in e-governance adoption within the Public Administration. Section 3 introduces our bibliometric approach, outlining the primary phases of the search process conducted in this study to retrieve pertinent scientific articles. The quantity of these articles surpasses those pertaining to digital transformation and human resources. Section 4 presents the application of correlation between digital transformation and human resources, revealing an almost exponential surge between 2020 and 2022, as elucidated. Digital transformation may bear implications for human well-being, influence social and ethical aspects, and lay the groundwork for prospective research avenues, as we explore in Section 5.

Conceptual Definitions

The rise of Human Resources Management signifies a relatively novel aspect within the Greek context, both academically and professionally. Greece's entry into the European Union in the early 1980s coincided closely with the commencement of the initial digital transformation phase, introducing concepts like technology, informatics, and further automation via e-governance. Businesses and consequently public sector entities embraced and sought to adopt optimal human resources management practices that had previously been put into action primarily by multinational corporations. Simultaneously, the presence of multinational corporations in Greece, along with economic uncertainties, provided additional motivation for numerous enterprises to adopt contemporary human resources management practices. Their goal was to ensure survival and sustain competitiveness in the modern business and labor landscape [4, 5].

The influence of digital transformation on human resources management is evident in the preference for recruiting talented young individuals with expertise and strong proficiency in digital technology. Digital technology underscores the necessity for employees to carry out their tasks swiftly, employing critical thinking, accountability, and an immediate response to customer demands. Consequently, specific personality and intelligence assessments are deemed essential from a personal standpoint, in addition to the fundamental assessments of digital skills.

The application of digital recognition, artificial intelligence, and mobile applications must be areas where employees possess adequate knowledge to be considered competent in addressing the challenges of the new digital era. Employees constitute an organization's most substantial resources and are regarded as its most valuable possessions. The nature and extent of their tasks have a direct impact on an organization's productivity. Fostering healthy employee relationships within an organization is a prerequisite for every business or entity, to achieve growth and enduring success [6].

Problem-solving extends beyond the basic memorization of facts and the mechanical application of set methods. Instead, it encompasses an intricate cognitive procedure that calls for advanced cognitive functions and digital proficiencies to effectively tackle the complexities and hurdles individuals encounter. Frequently, in numerous everyday scenarios, individuals are compelled to employ a range of cognitive processes to attain a particular objective. The procedures employed to mitigate the disparity between the initial state and the targeted state represent the fundamental components of problem-solving methodologies [7].

On one hand, the utilization of computers excels in adhering to rules, while on the other hand, it struggles with pattern recognition. The brain, by means of the senses, can perceive information and analyze it for patterns. However, it cannot precisely describe how this process occurs, particularly when dealing with a substantial volume of rapidly changing information presented at a high speed. Philosopher Michael Polanyi [8] notably asserts that we possess more knowledge than we are capable of articulating, suggesting that certain tasks cannot be digitized and will continue to rely on human involvement. The changes ushered in by digital technology will offer significant benefits, but they will fall short of completely supplanting human nature.

The widespread utilization of information systems by a growing number of governments, along with their corresponding administrative systems, has established a new trend regarding the utilization of e-governance by the Public Administration. In Figure 1 some of the key objectives are presented:

Fig 1: Key objectives of Public Administration

The Digital Economy and Society Index (DESI) for each country is included within the framework of the European Digital Decade program, addressing the aspects as presented in Fig. 2.

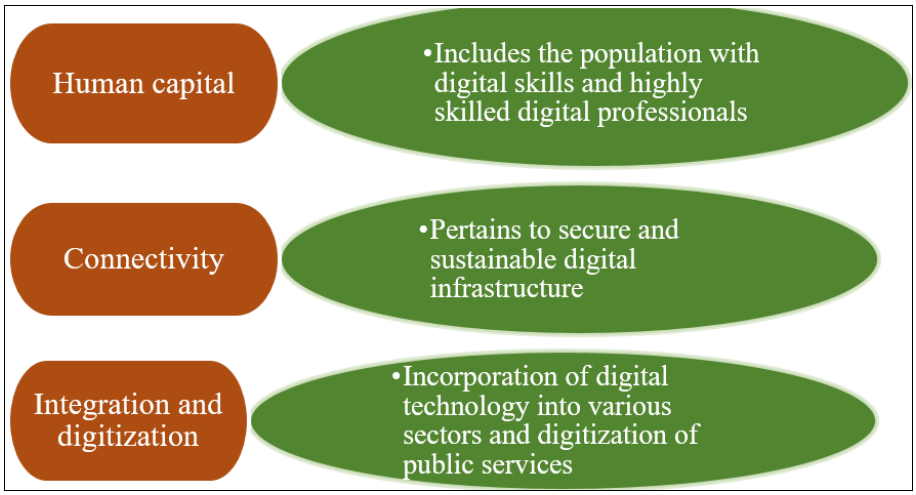

Fig 2: Aspects of DESI

In the Digital Economy and Society Index (DESI) for the year 2022, Greece ranks 25th among the 27 European Union member states. Nevertheless, despite this relatively low ranking, Greece has made satisfactory progress in recent years compared to other EU member states, achieving a score of 52%. Greece's score is in close proximity to the EU average of 54%. This suggests that Greece is effectively narrowing the gap and making strides to catch up with other countries.

Bibliometric analysis

Figure 3 illustrates the structure of this bibliometric approach and includes the main stages of the search process followed in this study to retrieve the appropriate scientific articles from the scientific databases. Once the topic and scope of the study were defined, parameters like the study's time horizon were established. Following this, the research questions that this study aims to address were formulated. The pertinent studies were subsequently saved in. RIS format from the Scopus database to undergo data processing. The VOS viewer software was employed to extract the keywords and their co-occurrences.

Finally, the findings of the present analysis are discussed, and useful conclusions are highlighted, along with suggestions for future research.

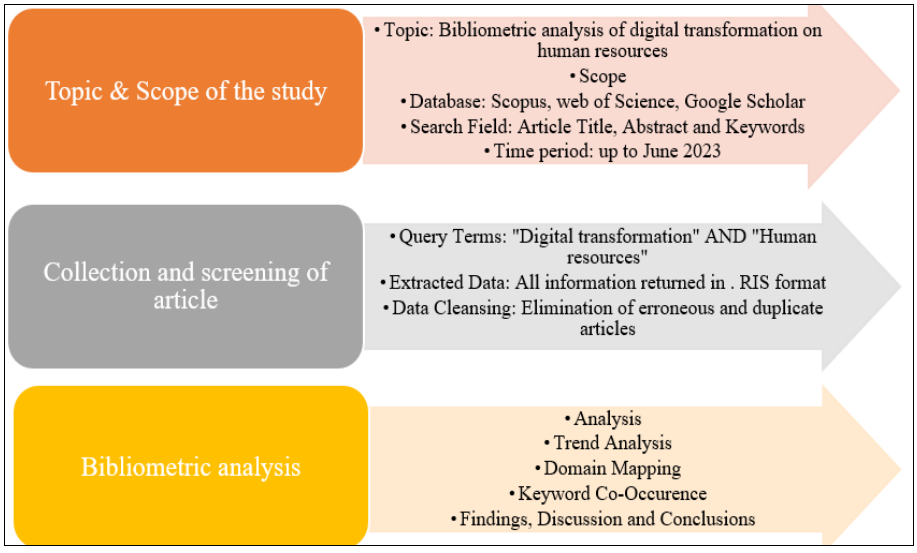

Fig 3: Structure of the bibliometric approach followed

In the present bibliometric analysis, distinguished scientific databases, namely Scopus, Web of Science (WoS) [23] and Google Scholar, were used to retrieve the scientific articles of interest and the datasets were stored in. RIS format. The relevant study research was performed in June 2023.

In Scopus, the search terms 'digital transformation' and 'human resources' were utilized, as well as combinations of these terms such as ['digital transformation' AND 'human resources'], ['digital transformation' OR 'human resources'], ['digital transformation' NOT 'human resources'], ['human resources' NOT 'digital transformation'], ['human resources' NOT 'digital transformation' and 'digital transformation' NOT ['human resources']]. Eventually, the search term ['digital transformation' and 'human resources'] was selected, as it yielded both a substantial number of results and a manageable volume of outcomes. It is worth noting that the search terms ['digital transformation' NOT 'human resources'], ['human resources' NOT 'digital transformation'], and ['human resources' NOT 'digital transformation' AND 'digital transformation' NOT ['human resources']] led to the same results.

For a more comprehensive comparison, searches were performed in the Web of Science database with very few results, as well as in Google Scholar with an extensive number of publications.

Given that both the Web of Science and Google Scholar databases produced either very few or excessively high numbers of results, the Scopus database was chosen as the primary source for conducting and processing studies.

This research has revealed that when using the terms 'digital transformation' and 'human resources' for searching in the context of Greece, only the following publications appeared as in Table 1.

Table 1: Publications of Greek researches.

Authors	Title	Year	Source title	Cited by
Mourtzis D., Xanthi F., Zogopoulos V. [9]	An adaptive Framework for Augmented Reality Instructions Considering Workforce Skill	2019	Procedia CIRP	32
Mitroulis, D., Tsiavos, V., Kitsios, F.C. [10]	Leadership as Success Factor for Digital Transformation and Innovation	2020	Springer Proceedings in Business and Economics	-
Messini V. [11]	Employer Branding in the Retail Industry: a Systems Approach	2022	International Journal of Applied Systemic Studies	-
Tsiavos V., Kitsios F. [12]	Technology as Driver, Enabler and Barrier of Digital Transformation: A Review	2022	Lecture Notes in Business Information Processing	1
Michalopoulos D., Karras A., Karras C., Sioutas S., Giotopoulos K.C. [13]	Neuro-Fuzzy Employee Ranking System in the Public Sector	2022	Frontiers in Artificial Intelligence and Applications	1

Table 2 summarizes the answers to the aforementioned questions,which were gathered from the search conducted using the Scopus database. Additionally, responses were collected from alternative databases of the terms "digital transformation", "human resources", and ["digital transformation" AND "human resources"] as well as in the alternative databases Scopus, Web of Science and Google Scholar.

Table 2: Number of occurrences of search terms in the databases.

Database	Search Query	Results
Scopus	“digital transformation”	17.064
Web of Science	“digital transformation”	7.062
Scopus	“human resources”	105.938
Web of Science	“human resources”	91.761
Scopus	“Digital transformation” and “Human resources”	535
Web of Science	“Digital transformation” and “Human resources”	124
Google Scholar	“Digital transformation” and “Human resources”	35.900

Results

Following the process described in the section above regarding data collection, the final examined dataset consists of 535 scientific publications, as presented in Table 2. This number of publications is considered relatively high compared to those concerning digital transformation and human resources, as the application of the correlation between digital transformation and human resources shows an almost exponential increase between the years 2020 and 2022. Considering that the digital transformation aims at the triad of 'people, data, and processes,' to enhance the organizational competitiveness, it is evident that the primary activity involved in every digital transformation effort is Human Resource Management. In recent years, particular importance has been attributed to the data for digital transformation, which is extremely abundant and can be combined and processed in various ways to yield rapid and actionable insights.

Trend analysis

An attempt has been undertaken to address the initial research question through the visualization of the annual number of publications related to the term 'digital transformation.' From the analysis of the publication count per year (Fig. 4), an explosion of publications related to the term 'digital transformation' is observed from 2020 onwards, even though this particular term appeared in the literature as early as 1968.

Trend analysis in number of publications per year on articles regarding “digital transformation”.

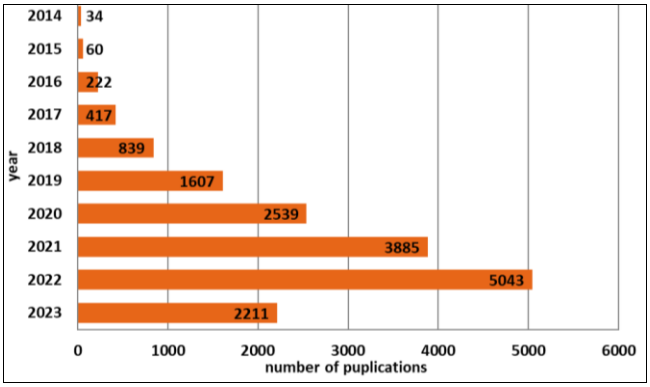

Fig 4: Trend analysis in number of publications per year on articles regarding “digital transformation

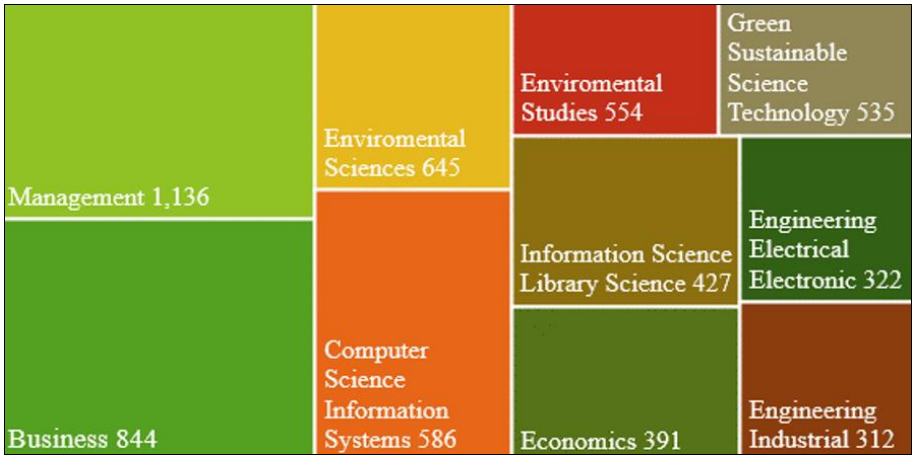

Fig 5: The top 10 Web of Science categories chart on digital transformation

Trend analysis in number of publications per year on articles regarding "Human Resources"

The process of analyzing the number of publications per year reveals that the appearance and increase in the number of publications related to the term 'human resources' have been observed from 2014 onwards, despite this specific term having appeared in the literature as early as 1917.

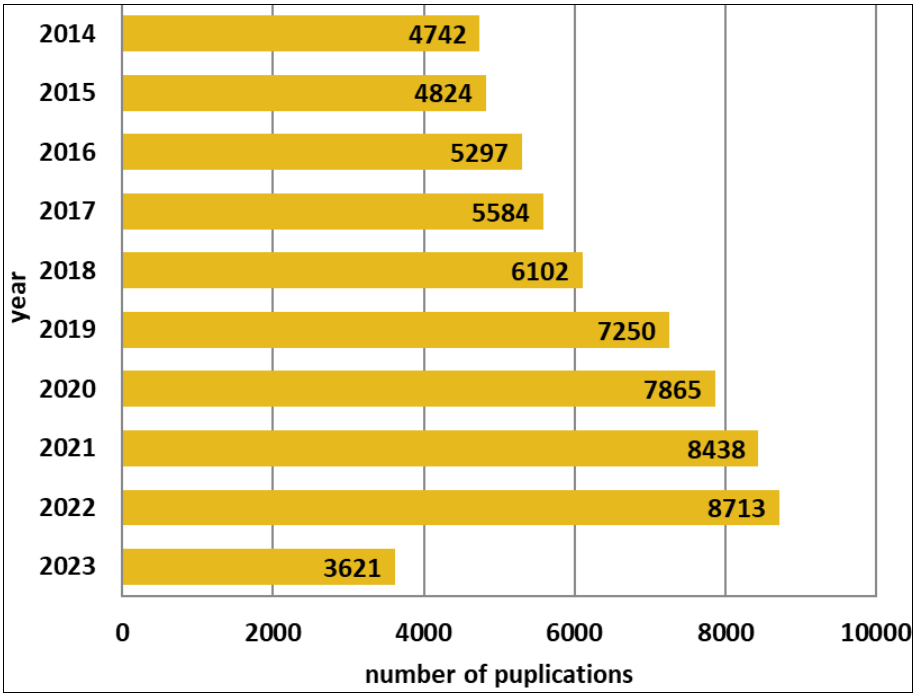

Fig 6: Trend analysis in number of publications per year on articles regarding "Human Resources"

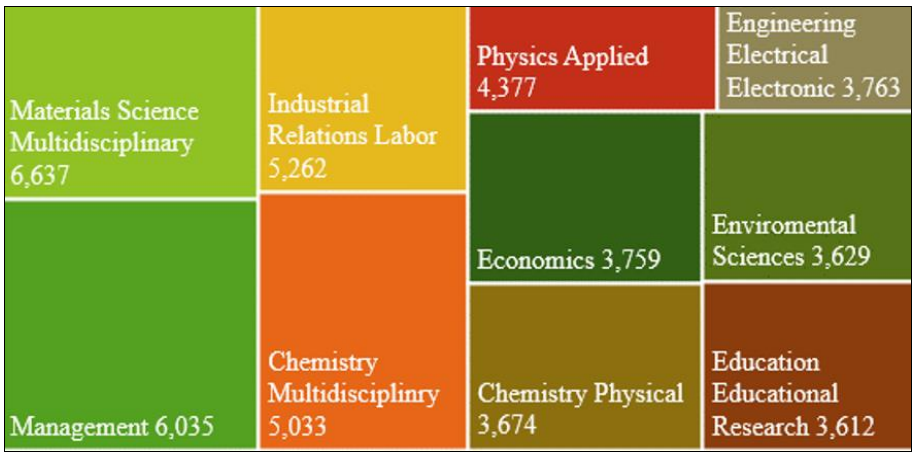

Fig 7: The top 10 Web of Science categories chart regarding "Human resources"

Trend analysis in number of publications per year on articles regarding "Digital transformation" and "Human resources".

The volume of publications related to the terms ['digital transformation' AND 'human resources'] can be discerned from 2009 onwards through the analysis of the number of publications per year. This is the year when the simultaneous appearance of both terms in the literature began.

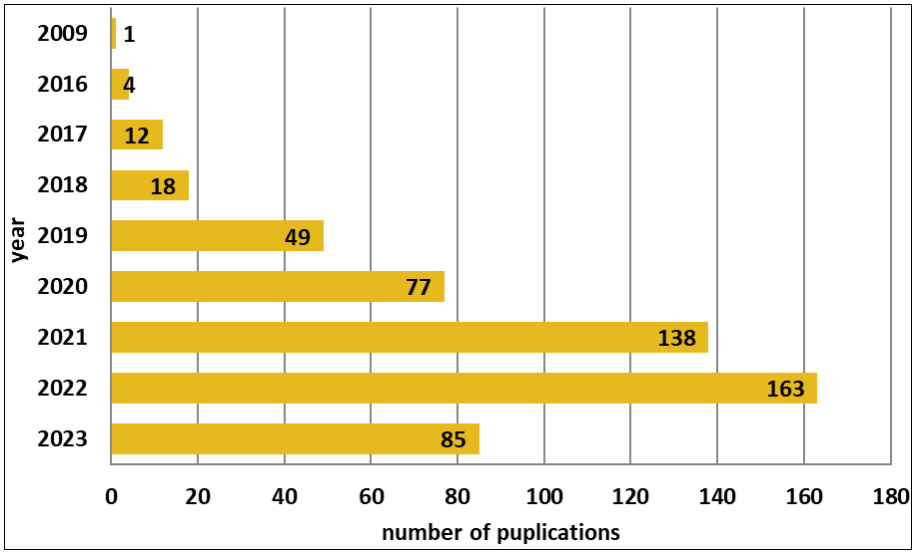

Fig 8: Trend analysis in number of publications per year on articles regarding "Digital transformation" and "Human resources

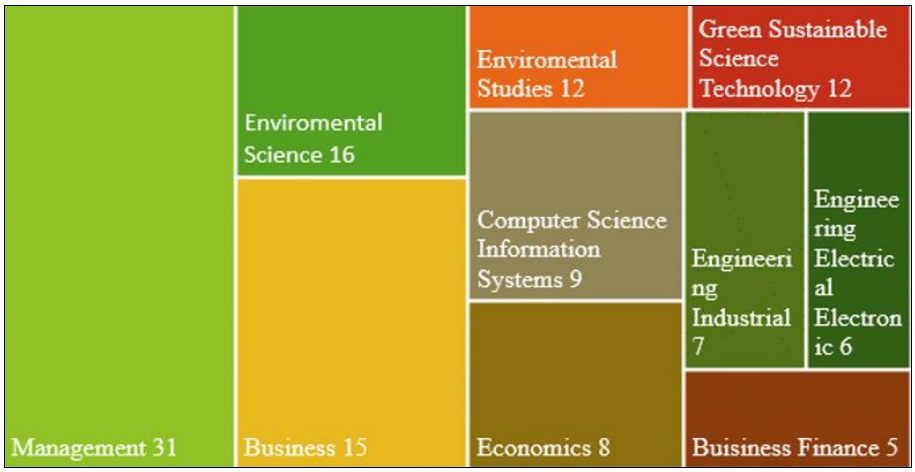

Fig 9: The top 10 Web of Science categories chart regarding "digital transformation" AND "human resources"

Subsequently, the eleven (11) thematic areas that have attracted the most research are being presented, based on the data recorded in Scopus.

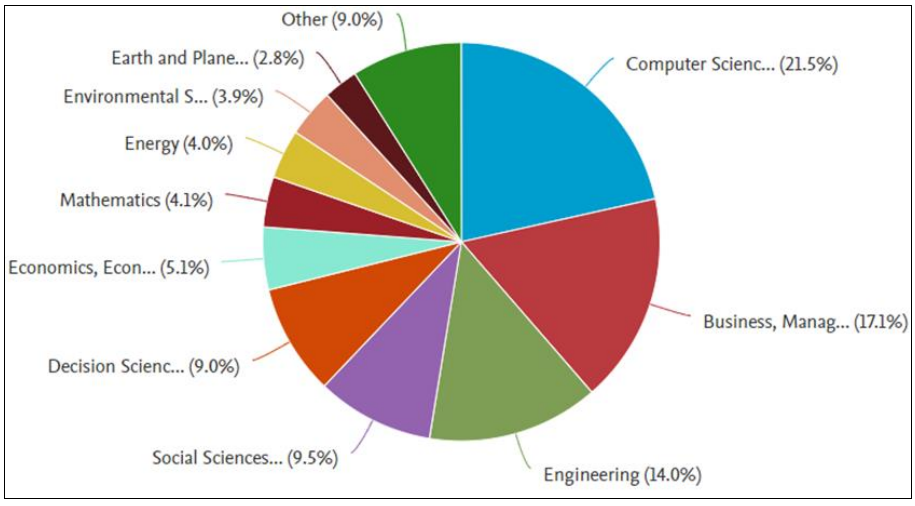

Fig 10: Documents distribution according to subject area regarding "digital transformation" and "human resources".

Citation Analysis (Scopus)

Citation analysis is a technique used to assess the impact and quality of a study by measuring the number of citations it receives from other studies. This method uses mathematical, statistical, comparative, and logical techniques to analyze scientific journals, papers and reference objects in order to determine the characteristics of a bibliometric analysis. The primary types of citation analysis include measuring the number of citations, examining citation relationships, and creating bibliometric maps as systems for organizing knowledge. The approach taken is limited to categorizing publications based on the number of citations they have received, with the aim of creating a bibliometric map. Specifically, the number of studies containing the terms "DT" and "HR" in the Scopus database was recorded with:

- At least 30 references.
- At least 20 references.
- 15 references.
- 10 references.
- 5 references.

Therefore, 111 studies have at least 5 citations, while only 21 studies have at least 30 citations. The data, which has been broken down by categories, is presented in Table 3.

Table 3: Number of studies with a given number of references

No. of citations per document	No. of documents
30	21
20	29
15	42
10	65
5	111

The 10 most cited studies are presented in Table 4.

Table 4: Most cited studies

Authors	Title	Year	Source title	Cited by
Teizer J., Wolf M., Golovina O., Perschewski M., Propach M., Neges M., König M. [14]	Internet of Things (IoT) for Integrating Environmental and Localization Data in Building Information Modeling (BIM)	2017	Proceedings of the 34th International Symposium on Automation and Robotics in Construction	58
Li L., Su F., Zhang W., Mao J.Y. [15]	Digital Transformation by SME Entrepreneurs: A Capability Perspective	2018	Information Systems Journal	383
Gregory R.W., Kaganer E., Henfridsson O., Ruch T.J. [16]	ITConsumerization and the Transformation of it Governance	2018	MIS Quarterly: Management Information Systems	98
Hausberg J.P., Liere-Netheler K., Packmohr S., Pakura S., Vogelsang K. [17]	Research Streams on Digital Transformation from a Holistic Business Perspective: a Systematic literature Review and Citation Network Analysis	2019	Journal of Business Economics	71
Caputo F., Cillo V., Candelo E., Liu Y. [18]	Innovating through Digital Revolution: The Role of Soft Skills and Big Data in Increasing Firm Performance	2019	Management Decision	70
Papadonikolaki E., van Oel C., Kagioglou M. [19]	Organising and Managing Boundaries: A Structurational View of Collaboration with Building Information Modelling (BIM)	2019	International Journal of Project Management	65
Fenech R., Baguant P., Ivanov D. [20]	The Changing Role of Human Resource Management in an era of Digital Transformation	2019	Journal of Management Information and Decision Sciences	51
Herceg I.V., Kuč V., Mijušković V.M., Herceg T. [21]	Challenges and Driving Forces for Industry 4.0 Implementation	2020	Sustainability	61
Trenerry B., Chng S., Wang Y., Suhaila Z.S., Lim S.S., Lu H.Y., Oh P.H. [22]	Preparing Workplaces for Digital Transformation: An Integrative Review and Framework of Multi-Level Factors	2021	Frontiers in Psychology	51
Chen C.L., Lin Y.C., Chen W.H., Chao C.F., Pandia H. [23]	Role of Government to Enhance Digital Transformation in Small Service Business	2021	Sustainability	49

Co-Occurrence Analysis

To perform the co-occurrence analysis of keywords, the search results from the Scopus database were relied upon. Within the literature, there are discussions regarding the preprocessing of primary data and the identification of publications. Moreover, there are considerations regarding limitations that must be considered when calculating and utilizing the number of citations. It is important to acknowledge that the number of citations received by publications is notably influenced by factors such as scientific disciplines, the time frame for report analysis, and the category of scientific publications [24].

For the construction and visualization of bibliometric networks, the VOS viewer software was used. Network visualization was employed for clustering data based on the simultaneous appearance of keywords. The resulting bibliometric graph represents each keyword as a point in a two-dimensional plane. The results are color-coded based on the similarity of each study, while the size of the node depicts the frequency of occurrences, with larger nodes corresponding to keywords with higher frequencies. Keywords that co-occur are connected by an arc, the width of which corresponds to the strength of co-occurrences, while the distance between nodes indicates term dissimilarity.

Table 5: Categorization of the co-occurring keywords in the 7 clusters

Cluster 1 (Red)	Cluster 2(Green)	Cluster 3(Blue)	Cluster 4 (Yellow)	Cluster 5 (Purple)	Cluster 6 (Light blue)	Cluster 7 (Orange)
Artificial intelligence	Digital technologies	Decision making (30)	Big data	Automation	Economics (13)	E-learning (28)

(38)	(31)		(18)	(12)		
Digital economy (23)	Human resources management (34)	Human resource management (229)	Industry 4.0 (54)	Business process (12)	Knowledge management (21)	Information and communication technologies (10)
Digital transformation (323)	Resource allocation (16)	Information management (53)		Efficiency (12)		Information systems (20)
Digitalization (46)	Sustainable development (16)					Information use (20)
						Software design (10)

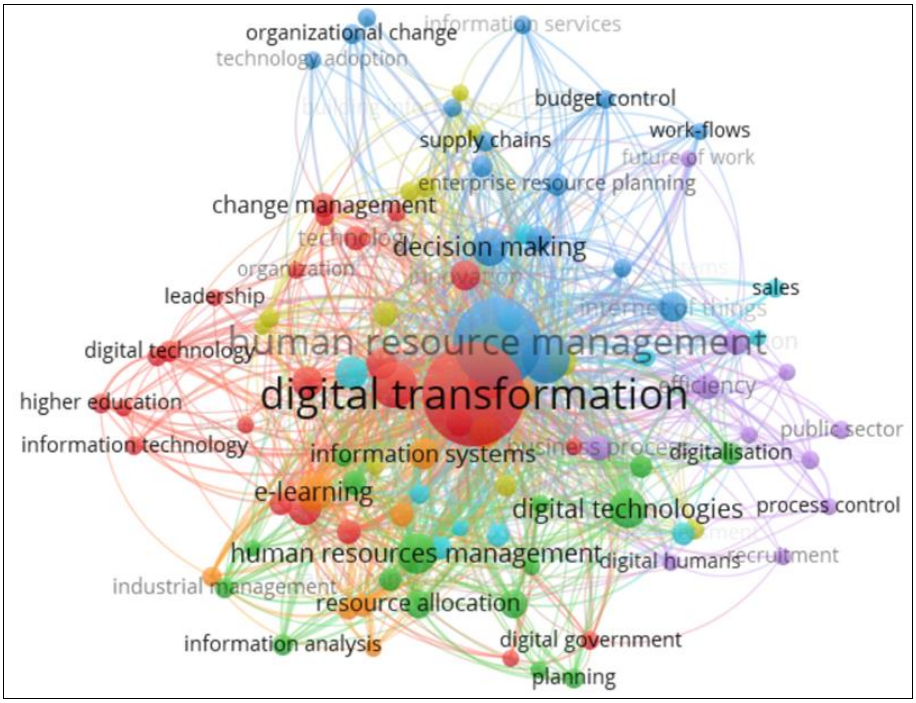

Fig 11: Summarizing the aggregated VOS viewer graph, the nodes (terms) with the highest frequency of occurrence in published articles are listed

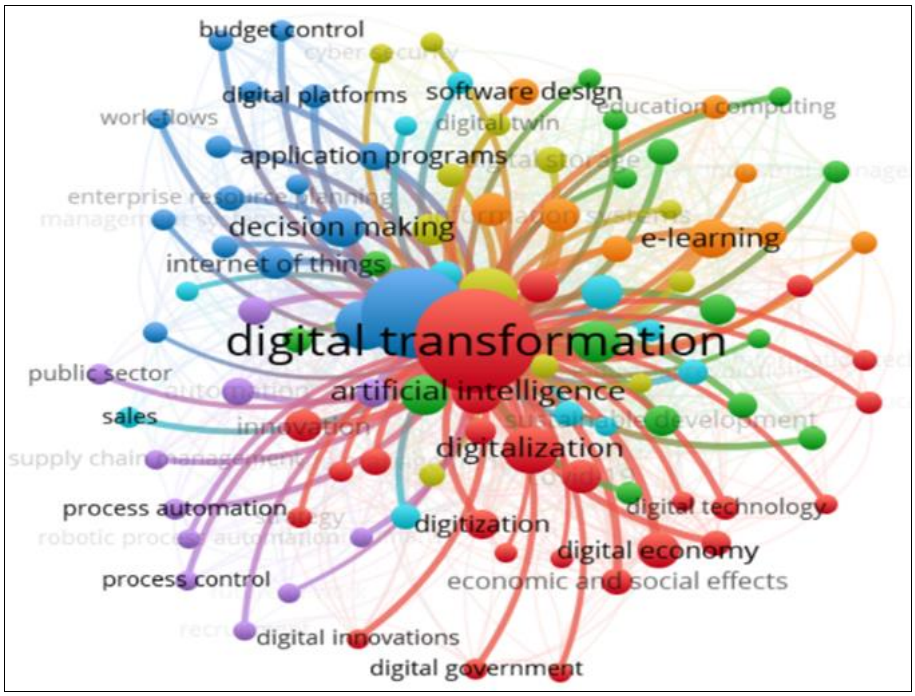

Fig 12: Co-occurrence map in digital transformation and keywords as captured in the 7 clusters, indicates the strong association between these terms

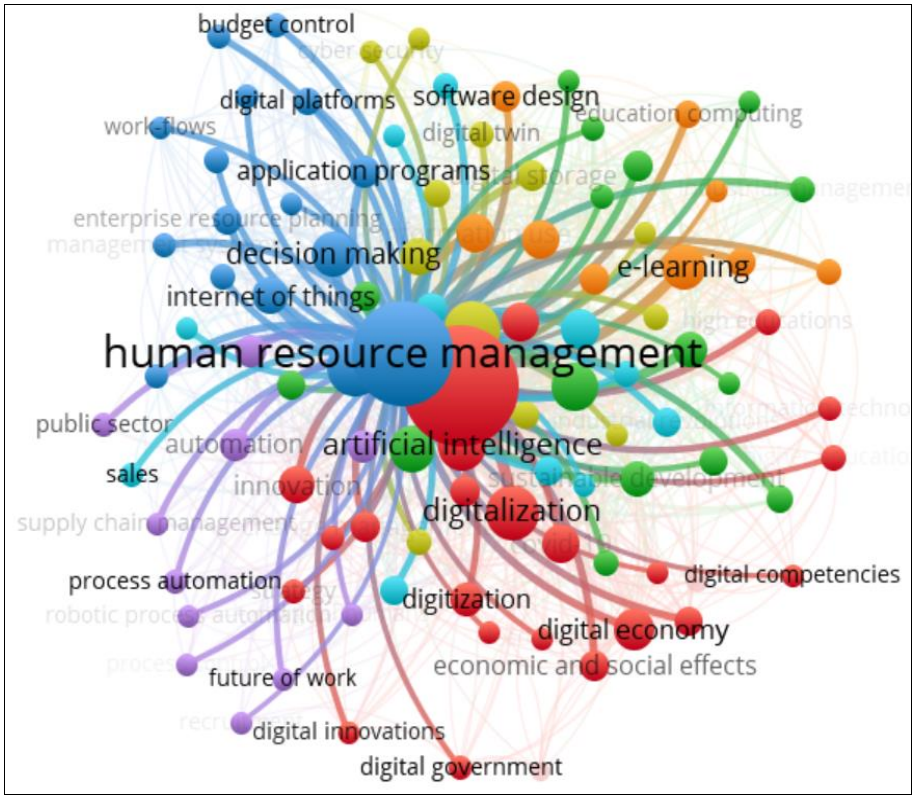

Fig 13: Co-occurrence map in human recourse(s) management and keywords as captured in the 7 clusters, indicates the strong association between these terms

In Table 5 we present the number of studies per category.

Table 5: Number of manuscripts per publication category

Publication Type	No. of Publications
Conference paper	256
Article	215
Book chapter	44
Conference review	11
Review	10
Book	9
Retracted	1
Data paper	1

Conclusions

The conducted bibliometric analysis provides insights into the current state of research, trends, and the impact of digital transformation applications in human resource management. The motivation behind this study was the increased interest in this specific research field, which has grown rapidly in recent years, mainly due to the latest developments in digital transformation. The analysis yielded significant results, and potential extensions of the ongoing research have been proposed.

Digital transformation is a phenomenon arising from the continuous evolution of technology, offering new opportunities and challenges that require further research exploration. The effective utilization of technology for the benefit of society and human resources constitutes a significant field of research.

One of the main aspects worth of investigation is the impact of technology on employee training. Beyond traditional training methods, it is important to explore how technology can support training through educational applications, virtual reality, and other advanced technologies. Furthermore, it is crucial to examine how organizations can adapt to digital transformation and provide their employees with the necessary knowledge and skills to meet the new demands of the job market [25].

Furthermore, it is worth exploring the impact of digital technology on the way we work. Topics such as remote work, human-robot collaboration, and workplace flexibility deserve further investigation to gain a better understanding of how technology influences organizational processes and work conduct.

Moreover, digital transformation can have implications for human well-being and impact social and ethical aspects. Research perspectives should focus on how digital transformation serves the common good and ensures that it respects values and ethical challenges arising from technology use. Additionally, the effect of digital transformation on the psychological, physical, and social well-being of individuals in their workplace needs to be explored.

In summary, further research on digital transformation and human resources offers significant opportunities for understanding the new dynamics created due to technological advancement. Additionally, it can provide specific directions for the effective utilization of technology for the benefit of human resources and society as a whole.

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