Examining Human-AI Collaboration in the Knowledge Work domain

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Abstract. This paper explores the evolving landscape of Artificial Intelligence integration into knowledge work, focusing on human-machine collaboration, through two methodological approaches. First, a bibliometric analysis was conducted to provide a quantitative overview on the subject. Subsequently, an integrative literature review was performed to propose an in-depth qualitative analysis. Trends topics, frequent terms, types of AI researched, challenges and opportunities to the human-machine collaboration were identified. The findings underscore a transition of academic research from a diverse range of AI technologies to a concentrated focus on generative AI. Furthermore, it suggests a growing emphasis on human creativity and in the importance for knowledge workers to develop not only basic technical skills but also intuitive and empathetic skills that complement AI's capabilities. This study offers a comprehensive overview of current AI impact on knowledge work, and provide opportunities for future research.

Keywords. Artificial intelligence, knowledge work, Generative AI, literature review, bibliometric analysis

1. Introduction

The transformative potentials of Artificial Intelligence (AI) technologies and the integration of these AI systems into numerous fields has been reshaping how we approach and execute intellectual and knowledge-based tasks. As technology advances, there is also academic and scientific endeavors to research how these digital tools affect the knowledge work. Moreover, due to the constantly evolve nature of AI systems, research the subject may quickly become obsolete, and constant investigation is necessary to reevaluate the state of the art.

The term "knowledge worker" was originally coined by Peter Drucker and subsequently refined by other scholars over time, being also described as an individual whose occupational pursuits are centered around the generation, dissemination, and utilization of knowledge [1]. Naturally, all forms of employment necessitate a certain degree of "knowledge", thereby the term itself may be ambiguous in certain contexts. However, in this research, we refered knowledge work as the kind of work that focuses on the generation, editing, processing, and transfer of knowledge and information [2].

Nowadays, new technologies based on Generative Artificial Intelligence have captured the interest of the academic and scientific community due to their disruptive potential in fundamentally altering the way organizations engage with knowledge creation and utilization. Literature has highlighted promising applications within the context of human-machine collaboration, while research on the subject increases in recent years [3]. However, there exists a gap in the in-depth investigation of the impact of AI focusing on the dynamics of collaboration between humans and systems in organizational knowledge processes [4].

The concept of human-machine collaboration is nothing new, still, due to the constantly evolve of AI, new dynamics may arise. Thus, research around human-machine collaboration may quickly become obsolete, and constant investigation is necessary to reevaluate the state of the art on the subject. In recognition of this opportunity, this study employs a combination of bibliometric analysis and literature review methodologies, discussed in the Methods section.

In this sense, to provide an general overview of the artificial intelligence intervention within the context of knowledge work, this study proposed a bibliometric analysis of metadata from Scopus database. Subsequently, a integrative literature review was conducted with a smaller sample, obtained from certain criteria, to provide an in-depth qualitative analisys. Therefore, the focus of the

literature review is to uncover the aspect of human-machine collaboration within the AI and knowledge work domain. Thus, the objective is to identify:

1. Whether the issue of collaboration arises when discussing AI and Knowledge Work; if so, how prominently it is in the academic literature.

2. Whether there are guidelines for human-machine collaboration within AI and Knowledge Work;

3. What challenges are encountered in this collaboration.

The findings from the bibliometric analysis provides a compreensive overview of trend topics within the object of study, allowing some insightful inferences. For example, despite some of the most frequent terms being cognitive workloads, automation and knowledge management, the trend topic from 2023 was "creatives", suggesting a potential shift towards human creativity in the face of technological advencements and evoling work dinamics.

Moreover, the reviewed literature underscore a pivotal transition catalysed by generative AI technologies, particularly with the advent of models like ChatGPT, marking a significant departure from traditional knowledge systems to more collaborative and generative AI-driven approaches.

2. Methods

This research consists of two parts. First, a bibliometric analysis from metadata obtained by Scopus database was conducted to provide a quantitative overview on the subject of AI within knowledge work context. Bibliometric studies provides insights into the relationships and interactions among research articles [5], and it is particularly suitable for science mapping [6].

The string was inicialy applied without time constraints, no filters of language, type of publication, nor any other exclusion criteria. The string utilized was *(("knowledge work*" OR "intellect* work*" OR "cogni* work*" OR "information work*" OR "creative work*") AND ("Artificial Intelligence" OR "AI" OR "machine learning" OR "natural language processing" OR "deep learning" OR "automation" OR "robotics"))*, returning 1.405 results. The data were analyzed using bibliometrix package for R [6], and the results are subsequentially discussed in section 3.

Additionally, a integrative literature review [7, 8], was also conducted, which is essentially an empirical qualitative analysis. The data interpretation methodology is based on thematic analysis [9]. Data were refined within the first results obtained from the bibliometric analysis of Scopus database, and complemented with data from Web Of Science database, as they have a multidisciplinary nature, allowing for broader coverage of areas. The following inclusion and exclusion criteria were then applied to

narrow down the results:

1. Type: Only journal papers were included. Conference papers, book chapters, and other types of literature were excluded.

2. Language: Only papers in English language were included. Papers in other languages were excluded.

3. Recency: Since Artificial Intelligence has undergone significant transformations in recent years, only studies from the last five years (2019-2024) were included.

Subsequently, the duplicated files were excluded, leaving 104 different papers. After reading the abstracts, we applied the last exclusion criteria, which is relevance to the topic. Therefore, papers that only briefly mention Artificial Intelligence or use the term as a keyword but do not delve into the subject in their study were also excluded. Figure 1 represents the numbers obtained from the research string and the selection proccess that leads to the final sample of 28 papers.
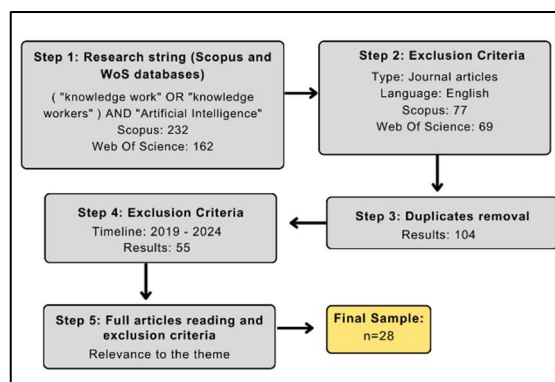

Fig. 1 – final sample selection process

These articles were fully read, and a synthesis matrix was developed to summarize the methods employed, the key findings, the type of artificial intelligence analyzed, and the extent to which the research addresses human-machine collaboration (HMC). The human-machine collaboration aspect was then categorized as follows: 1) HMC is not the main focus of the study; 2) the study indirectly addresses it, and 3) HMC is the main focus of the study. These aspects towards collaboration between human-machine are presented in Table 1, and subsequently discussed in section 3.

3. Analysis and discussion

3.1 Biliometric analysis

As mentioned before, the first part of the analysis consists of a bibliometric analysis to provide a more quantitative overview, from 1405 papers without exclusion criteria such as time constraints. Figure 2 represents the annual production of articles on the subject. The first part of the analysis, based on the 1.405 results from the Scopus database, is limited to a year range of the last 50 years, therefore, the first paper appears in 1974.
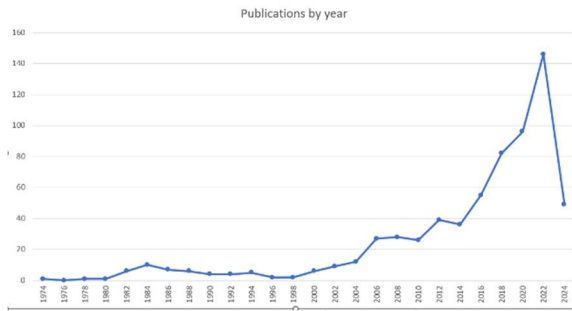
**Fig. 2 –** publications by year. Biliometrix for R

As show in Figure 2, publications on the subject were modest until the 2000s, but began to slightly increase after 2005. There is a significant rise from 2020 onwards. As expected, a peak is observed in 2023, which may be related to the release of ChatGPT in November of 2022. As of the time of this research (March of 2024), publications amount in 2024 are approximately 25% of those published in 2023, suggesting a potential continuation of the trend. The bibliometric analysis shows and Annual Growth Rate of 8.09%.

Figure 3 represents a word cloud of the keywords, were the most prominent, after "artificial intelligence" are "cognitive workloads", "automation", "human", "knowledge workers" and "knowledge management".

Fig. 3 – publications by year. Biliometrix for R

However, despite the prominence in the overall keywords, a new shift becomes evident when compared to Figure 4. Figure 4 is a graphical representation of trend topics, based on keyword plus metadata from 2014 to 2024, with a minimum term frequency of 20.
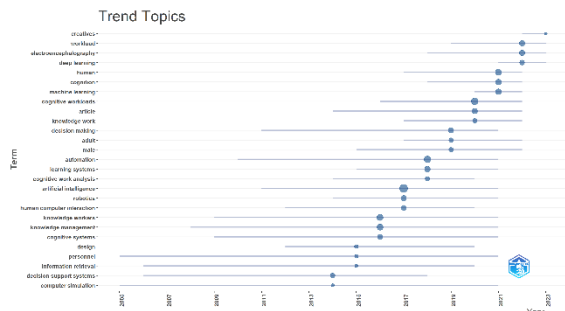
Fig. 4 – Trend topics. Biliometrix for R

From the most prominent keywords, Cognitive

workloads and Knowledge work appear as trend in 2020; Cognition and Machine Learning in 2021; Automation was a trend in 2018; Robotics and human-computer interaction in 2017; and Knowledge Management was a trend in 2016. Nowadays there is a shift towards the term "creatives", the most frequent in 2023.

These findings from the bibliometric analysis allow some insightful inferences. For exemple, the term "creatives" being a trend in the last year may suggest a potential shift towards human creativity in the face of technological advencements and evoling work dinamics. With the automation of routine tasks, the knowledge work that require even more human-centered cognitive skills, including creativity. As a result, understanding how to cultivate and leverage creativity in the knowledge work appears to be increasingly important.

3.2 Literature review

The studies reviewed seems to face some nomenclature obstacles regarding AI, making categorization in RSL difficult. A variety of terms appear, such as assistants, conversational agents, machine learning, sometimes even algorithms. Some papers do not mention a specific AI but rather addresses it in generic terms, especially when the focus is more centred on humans. In this sense, we consider important to identify more specifically what type of AI is being discussed. The references regarding the types of AI analyzed and how the sudies address the human-machine collaboration (HMC) are presented in Table 1.

Tab. 1 – Types of AI studied and HMC classification.

AI	HMC is not the focus	Indirect address HMC	Focus on HMC
Chatbots (non LLMs) and personal assistants		[10]	[11]
GPT, LLMs and GenAI	[12, 13]	[14, 15]	[16-19]
Machine Learning		[20, 21, 35]	[22]
Cognitive automation / Cognitive Computing Systems	[23, 24]	[21, 25, 37]	
Knowledge-based systems / expert systems	[26, 36]	[4]	
Robotics / RPA	[24, 36]	[20]	
Others			[27]
Ai in general or non-specified	[28]	[29-33]	[34, 38]

From these studies, an evolutive timeline can be observed. From 2019 to 2021, research on AI within knowledge work appears to encompass a broader range of AI types, such as Expert systems and Knowledge-based systems, [4, 26, 36] while also covering robotics and robotic process automation (RPA) [20, 24, 36], chatbots, cobots or personal assistants [10, 11], cognitive computing systems (CCSs) and Cognitive automation [21, 23-25]. In 2021, [16] already utilized GPT3 to research issues of human workforce substitution. By 2022, researches focused mainly in machine learning and deep learning, like image recognition [22] along with cognitive automation [21]. However, not surprisingly, from 2023 onwards the focus on AI is majorly on generative AI such as ChatGPT [12-16, 19].

Therefore, the science surrounding the subject were more diversified before ChatGPT, encompassing chatbots and personal assistants, but also focusing on machine learning, cognitive automation, robotics, CCSs, and other AI systems. Nowadays, it gravitates towards textual generative AI.

Regarding the main findings of the reviewed studies, some researches suggests that there will be a substitution of human labour [23], while others consider this to be an exaggerated hype [24], and that there will be an increase in human skills instead [11]. While some suggest the erosion of skills and the need for new ones [37], others highlight the opportunity of augmenting human skills [2, 20, 33, 15]. There is a concern about creativity loss [35] and the need to differentiate knowledge created by humans and by machines [19]. This discussion is ongoing and there is no consensus within the scientific community.

Challenges around privacy concerns and social impacts [14, 18], along with transparency [10, 15, 25, 27] also appears. Regarding the opportunities observed in the literature review, studies suggests that collaboration between humans and AI leads to increased productivity and better results [11]. Moreover, AI is found to support humans in knowledge creation, sharing and learning, augmenting human capabilities and fostering a more intelligent knowledge environment [38].

Ethical considerations are mentioned in some studies [14, 15, 20], and present additional complexity, but are comparatively less studied in the analysed papers, which suggests the need for further exploration on the ethical aspects of human-AI collaboration in knowledge work.

4. Final considerations

The integration of AI into knowledge work has, as expected, several challenges and opportunities, which requires a multifaceted approach that considers both technological and human dimensions. The evolving landscape of artificial intelligence (AI) has fundamentally altered knowledge work, it is a new era for knowledge generation and utilization. The literature predominantly addresses the general

utilization of AI to enhance human productivity, theoretical discussions on substitutions at a conceptual level (with little discussion on which tasks may genuinely cease to exist) along with the risks posed to human skills.

There is a diversity in the types of AI explored in the literature, but the sometimes-ambiguous nomenclature highlights a critical aspect on the AI literature, at least in the context of knowledge work. Thess unclear definitions presents a challenge to the categorization and understanding of findings to academic settings. Additionally, at the policy level, there is a need for frameworks that support the ethical deployment of AI in knowledge work. Policies should aim to mitigate risks associated with job displacement and skill erosion while fostering an environment that encourages innovation through the ethical use of AI.

Prior to ChatGPT, the scientific research focus was on other chatbots or conversational agents, virtual assistants, cobots, cognitive automation, and machine learning, among others AI systems. However, since 2023, the majority of works within this this review take into account the impact of generative AI in the knowledge work domain. The rapid advancements in AI introduced new dynamics in the "human-AI partnership". The trend towards generative AI is a critical shift from mere automation to a deeper, more integrated form of collaboration, where AI's role in augmenting human intelligence becomes more prominent. This transition suggests a move towards leveraging AI for enhancing creative and analytical tasks, reshaping knowledge work.

The overall findings of this research provide opportunities for future research. Academically, there is the need for ongoing research that keeps pace with the rapid evolution of AI. Therefore, Future studies should aim to refine the conceptualization of AI in knowledge work with a particular focus on generative AI. Moreover, exploring the real-world impacts of AI on knowledge work through longitudinal studies could provide deeper insights into the long-term effects of human-machine collaboration. There are also implications for practitioners and professionals. The findings underscore the importance of developing a workforce that is not only technically proficient but also equipped with intuitive and empathetic skills that complement AI's analytical capabilities. Organizations should invest in training and development programs that prepare employees for a future where human-AI collaboration is the norm rather than the exception.

5. Acknowledgement

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