SACJ 37(1) June 2025
Research Article

Generative AI: Concerns, usage, challenges, opportunities and sentiments

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ABSTRACT
Despite widespread adoption and enthusiasm, Generative AI faces persistent technical challenges, prompting the need to understand its broader impact. This study employed bibliometric analysis to examine scholarly discourse and key drivers of Generative AI adoption. The findings reveal the key factor driving adoption as transdisciplinary collaboration regardless of region; the concerns relate to inconsistent accuracy, demanding infrastructure, and ethical and privacy issues. Generative AI's rapid proliferation, spurred by ChatGPT, marked a post-digital era marked by transformative innovations across multiple fields. The scholarly discourse has grown by 3,164%, reflecting its significant influence on research and disciplinary progress. Education, medical, and biomedical sectors lead in adoption, to enhance teaching experiences, diagnostics, personalised medicine, and pandemic responses. However, the digital divide persists, leaving certain demographics and regions unable to access its benefits equally. The absence of robust ethical, legal, and regulatory frameworks further exacerbates these challenges. This study reveals Generative AI's transformative potential and its ability to bridge disciplines despite technical hurdles. The study makes recommendations for education reform to embrace new curricula, for practitioners and policymakers to create flexible workforce options, to proactively address important ethical, legal, and regulatory considerations; and to be intentional about bridging the widening digital divide.

Keywords artificial intelligence, generative AI, ChatGPT, bibliometric, ethics, scoping review, sentiment analysis, transdisciplinarity, post digital theory

Categories • **Applied computing** ∼ **Computers in other domains** • *Computing methodologies* ∼ *Artificial Intelligence*

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Article history
Received: 27 June 2024
Accepted: 21 January 2025
Online: 2 July 2025

1 INTRODUCTION

Machine Learning (ML), Artificial Intelligence (AI), and Natural Language Processing (NLP) have advanced rapidly in recent years, enabling the creation of powerful platforms like ChatGPT and other Generative AI (GenAI) models, which are collectively referred to as Large Language Models (LLMs). While AI embraces a broad spectrum of technologies aimed at simulating human intelligence, GenAI specifically focuses on generating new content such as text,

Twinomurinzi, H., and Gumbo, S. (2025). Generative AI: Concerns, usage, challenges, opportunities and sentiments. *South African Computer Journal* 37(1), 120–145. https://doi.org/10.18489/sacj.v37i1.17890

SACJ is a publication of *SAICSIT*. ISSN 1015-7999 (print) ISSN 2313-7835 (online)

images, or code by learning patterns from existing data (Hagos et al., 2024). GenAI technologies were initially discovered and developed in the mid-2010s but their widespread recognition surged from November 2022, following the launch of ChatGPT by OpenAI. ChatGPT reached over a million users within just five days of its launch, marking a pivotal moment that demonstrated the practical applications of GenAI and accelerated its widespread acceptance. This paper builds on preliminary findings presented at the South African Institute of Computer Scientists and Information Technologists (SAICSIT) 2023 Conference, extending the analysis to provide a more comprehensive exploration of GenAI's transformative potential, challenges, and societal implications (Twinomurinzi & Gumbo, 2023).

The core components of ChatGPT, and by extension other GenAI models, are constructed on three foundational building blocks; the transformer architecture, pre-training process, and fine-tuning process (Iskender, 2023). The transformer architecture utilises a neural network that is able to analyse large datasets at scale to allow for parallel processing of input data. Previously, the transformer model relied on self-attention mechanisms, which enhanced its ability to process sequential data efficiently. This foundational concept was later significantly advanced and expanded upon with the development of the Generative Pre-trained Transformer (GPT) series which used generative pre-training to learn language patterns from extensive text data. GPT-2 advanced the technology with multi-task training, improving the model's ability to generalise across various tasks. GPT-3 increased the model size, improving its fluency and comprehension capabilities (Iskender, 2023). With InstructGPT, the focus shifted towards integrating human feedback into the training process, resulting in more accurate and context-aware responses. The development of ChatGPT and GPT-4, meant GenAI was not only scaling up in size, but also integrating human feedback mechanisms (prompts) and the capacity to process image inputs (Iskender, 2023; OpenAI, 2025; Temsah et al., 2024; Zhong et al., 2024). Building upon these advancements, OpenAI also recently introduced the o1 model, which includes enhanced reasoning capabilities to reduce hallucinations and instances where AI generates incorrect or fabricated information (OpenAI, 2025). This improvement is particularly crucial in fields like healthcare, where accuracy is critical. For example, o1 has demonstrated superior performance in generating coherent and accurate radiology reports, outperforming other evaluated models (Temsah et al., 2024; Zhong et al., 2024).

GenAIs are versatile and, therefore, extend to a wide range of use cases, with about 75% of their value projected across the four key areas of customer operations, marketing and sales, software engineering, and R&D (McKinsey & Company, 2023). In customer operations, GenAI enhances customer experience and agent productivity. In marketing and sales, GenAI revolutionises content creation and personalisation. It facilitates the generation of personalised messages and marketing materials suited to individual customer preferences, behaviours, and interests. GenAI's capability extends to creating advertisements, social media posts, and product descriptions, substantially enhancing the productivity and creativity of marketing functions. In software engineering, GenAI is redefining the coding process by treating computer languages as natural languages. This transformation allows software developers to complete tasks 56% faster (McKinsey & Company, 2023). GenAI's influence in R&D is significant, particularly in accelerating the development of new drugs and materials. For example, in the life sciences and chemical industries, GenAI foundation models are being used to generate candidate molecules, significantly speeding up the R&D process (McKinsey & Company, 2023). These advancements across different sectors illustrate the extensive impact of GenAI, not just in enhancing current practices but also in paving the way for novel approaches and efficiencies in various sectors. The technology's ability to understand and generate natural language plays a pivotal role in this transformation, marking a significant leap in automation and innovation potential. These examples highlight the versatility and potential of GenAIs to enhance productivity, streamline content creation, and improve the efficiency of text-related tasks in various domains. However, to ensure their responsible and ethical deployment in real-world applications, it is important to carefully consider the ethical implications and technological challenges associated with the use of GenAI. There are, therefore, divergent discourses surrounding the use of GenAI tools such as ChatGPT and similar GenAI. For example, Italy initially banned ChatGPT citing privacy and data infringement concern (McCallum, 2023).

The main objective of this study was to provide a holistic view of the usage, concerns, challenges, and optimisms of GenAI. A bibliometric analysis was done using the Scopus and Web of Science (WoS) databases, and the identified publications were analysed and visualised using Bibliometrix® and VOSViewer® tools (Aria & Cuccurullo, 2017; VOSviewer, 2025). Specifically, the study sought to answer the following research question:

How are prevalent patterns of GenAI usage represented in scholarly discourse, and what key factors are identified as driving the adoption of these technologies?

The study contributes to our understanding of GenAI integration and its societal impact. Firstly, it provides insights into the transdisciplinary dynamics shaping GenAI adoption across diverse sectors, highlighting the complex relationships between technological advancements, ethical considerations, regulatory frameworks, and societal values. Secondly, it offers an analysis of the ethical challenges inherent in GenAI development and deployment, shedding light on issues of bias, fairness, transparency, and accountability, and proposing strategies to navigate these ethical dilemmas responsibly. Thirdly, the study contributes to the discourse on regulatory governance and policy interventions necessary to ensure the responsible and equitable integration of GenAI, emphasising the importance of adaptive regulatory approaches that balance innovation incentives with societal values and individual rights. Lastly, the research underscores the need for inclusive and participatory approaches to GenAI development and deployment, emphasising the importance of engaging diverse stakeholders in transparent and informed discussions about the opportunities, risks, and ethical implications of GenAI.

This study distinguishes itself from other similar bibliometric reviews of GenAI by adopting a broad, cross-disciplinary lens to explore the impacts, going beyond domain-specific focuses like ChatGPT's role in healthcare (Lopes, 2024) or education (Liu et al., 2024). Unlike Khan et al. (2024), which emphasises general trends and geographic analyses, or R. Dwivedi and Elluri (2024), which limits its scope to technical fields and topic modelling, our study employs inductive thematic analysis to uncover richer insights across disciplines. Also, by separating pre- and post-ChatGPT trends and addressing GenAI's role in stimulating new fields and educational reform, this study offers a unique and forward-looking perspective on GenAI's transformative potential.

The remainder of the study is structured as follows: The next section provides an overview of the methodology employed to conduct the study followed by the results and discussion. Finally, the contributions, limitations, conclusions of the study, and proposed research agenda are presented.

2 RESEARCH METHODOLOGY

Bibliometric analyses are increasingly popular as a means to identify trends in data, such as the influence of authors, the most cited articles, and top contributing countries (Aria & Cuccurullo, 2017). In this study, we employed the method to explore the scholarly discourse on GenAI, focusing on its usage, challenges, opportunities, concerns and sentiments. The process involved collecting, analysing and visualising data, and then reporting the findings and inferences.

For the data, we conducted a search of Scopus and WoS on 9 November 2023 using the search string: ('Generative AI' OR 'generative artificial intelligence' OR 'AI generation' OR 'GenAI' OR 'ChatGPT' OR 'large language models'). We used WoS and Scopus because they are compatible with bibliometric tools like Bibliometrix®, ensure high-quality data, and currently represent the most practical options. Grey literature was not included to maintain a focus on peer-reviewed, high-quality, and standardised academic sources, which are critical for ensuring rigour and replicability.

We retrieved 3320 articles from Scopus and 1869 articles from WoS. Since we preferred peer-reviewed publications, we narrowed down the list to include only refereed journal articles and conference publications. We also included journal articles in press. Additionally, we limited the search to only those in the English language resulting in 1987 articles on Scopus and 1211 on WoS. After merging the two datasets, removing duplicate articles, and a peer review of each abstract and title, we found 1314 documents with missing abstracts or unrelated to GenAI leaving a total of 1884 documents. Biblioshiny, an online interface for Bibliometrix®, was used to analyse and visually represent the bibliometric data. We also conducted the thematic analysis manually, and sentiment and usage analyses using OpenAI's interface guided by the results of the manual analysis. Figure 1 gives a visual representation of the method.

3 RESULTS AND DISCUSSION

3.1 Main Information

In the scoping review shown in Table 1, we manually delineated the document analysis into two distinct periods: 2012–2022, specifically 30 November 2022 when ChatGPT was released, and 01 December 2022–2024, to capture the evolving dynamics of GenAI, particularly highlighting the pivotal role of ChatGPT's emergence as a significant turning point (Twinomurinzi

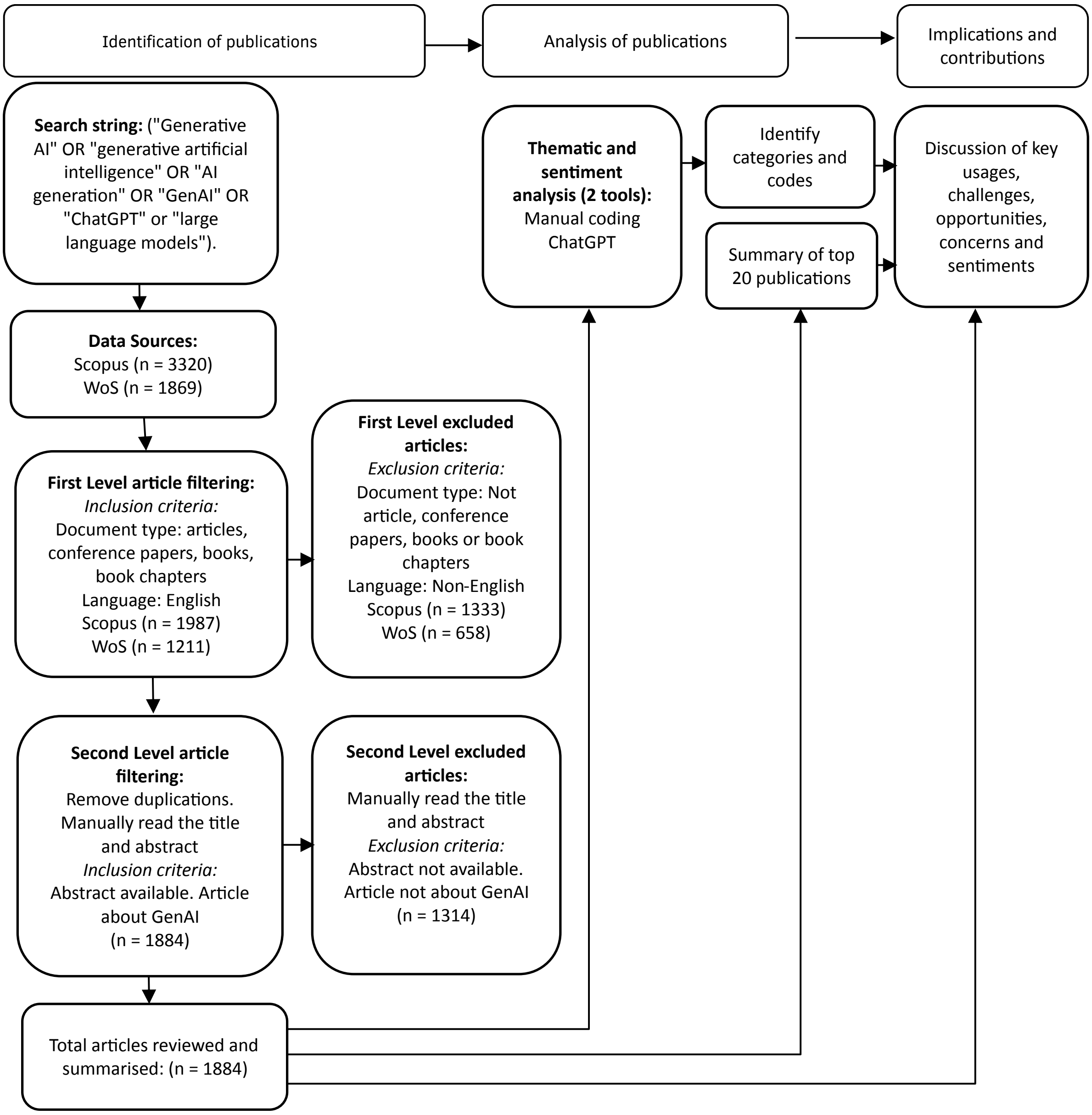


Figure 1: Schema for identification of research articles and analysis of results

& Gumbo, 2023). The first period, 2012–2022, had 56 documents from 34 sources, with a steady growth rate of 37.97%, an average number of 4.39 co-authors per document, and 26.79% in international collaboration.

The second period, 2022–2024, revealed a sharp increase in research activity, with 1828 documents from 941 sources. The interest and research output grew exponentially by 3,164%, and with the number of authors surging to 6283. The average co-authors per document was 4.01, and a slightly lower rate of international collaboration at 22.98%. This period also saw

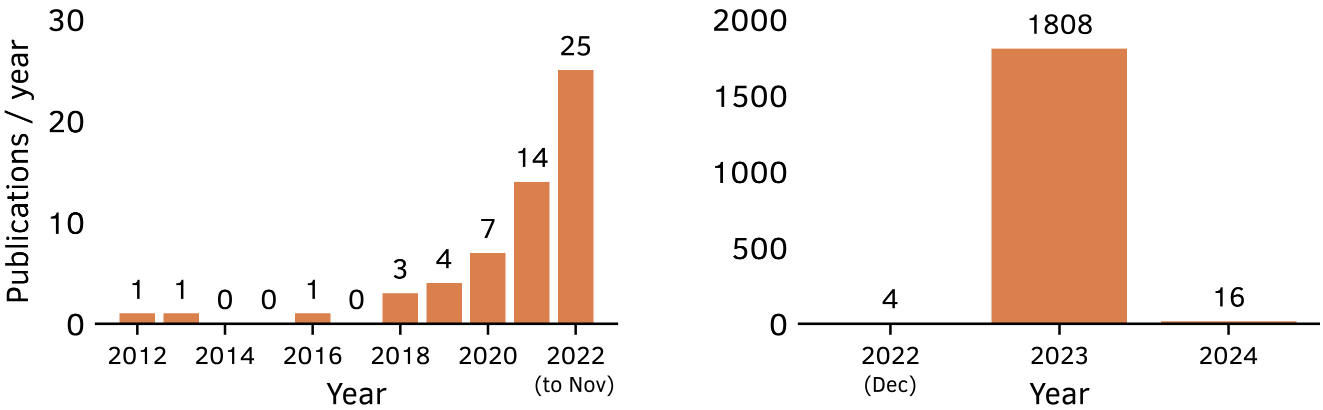
Table 1: Summary of the documents analysed

Main information about data	Results		
	Overall	**Period 1**	**Period 2**
Timespan	*2012–2024*	*2012–2022*	*2022–2024*
Sources (Journals, Books, etc.)	962	34	941
Documents	1884	56	1828
Annual Growth Rate %	*25.99%*	*37.97%*	*3164.29%*
Authors			
Authors	6423	184	6283
Authors collaboration			
Single-authored docs	336	5	320
Co-authors per document	4.02	4.39	4.01
International co-authorships %	*23.09%*	*26.79%*	*22.98%*
Document types			
article	1256	13	1243
article; early access	40	0	40
book	4	0	4
book chapter	27	2	25
conference paper	557	41	516

a notable increase in journal articles, including early access articles, and a substantial rise in conference papers to 516. ChatGPT was definitively an inflection or tipping point for GenAI and AI usage (Twinomurinzi & Gumbo, 2023).

3.2 Annual Scientific Production

The publication trends between 2012–2022, Figure 2(a), indicates a slow and steady increase in publications peaking at 25 publications until November 2022, suggesting a nominal interest in GenAI. In contrast, the period December 2022–2024, in Figure 2(b) reveals an explosive growth from 4 publications in December 2022 to 1808 in 2023. The sharp reduction in 2024 reflects the 16 early access publications in the forthcoming 2024.



(a) 2012 to November 2022

(b) December 2022 to 2024

Figure 2: Annual scientific production of GenAI

3.3 Top 10 Country Specific Production

Between 2012–2022, the scholarly discourse on GenAI was predominantly led by the United States of America (USA), which contributed 137 publications, nearly twice the total output of the nine other leading countries in GenAI research combined, 75 publications (Table 2(a)). China followed with 20, marking a substantial gap from the top article producer, USA. The presence of the Netherlands (9), Germany (8), Greece (7), Ireland (7), and Switzerland (5) reveals Europe's contribution in the first period. Japan (8), Canada (6), and Argentina (5) represented Asia, North America, and South America, respectively, depicting a nearly global diversity in scholarly production. Notably, African countries were absent. In the subsequent period (2022–2024), the USA maintained its lead with 1877 occurrences (Table 2(b)). China also saw a substantial increase to 639, reinforcing its position as a global research producer. In Europe, Germany (348), the United Kingdom (UK) (315), and Italy (299) were in the lead. Australia (286) emerged in the top 10, suggesting its growing role. Asia's expanded role had India (252), South Korea (143), and Singapore (126). Canada (138), showed a slower growth rate compared to other leading countries. Both periods had no representation from Africa in the top 10.

3.4 Most relevant sources

Between 2012–2022 (Table 3(a)), the sources were centered around Computer Science, particularly in specialist AI conference series. Between 2022–2024 (Table 3(b)), there was a significant shift in the scholarly discourse on GenAI, with the medical and biomedical fields emerging as the new leaders. This transition marks an increased integration of GenAI technologies in healthcare, particularly in diagnostics, personalised medicine, and pandemic response, reflecting the sector's growing reliance on GenAI.

Table 2: Country and continent specific production

(a) 2012–2022

#	Country	Continent	count	%
1	USA	North America	137	64.6%
2	China	Asia	20	9.4%
3	Netherlands	Europe	9	4.2%
4	Germany	Europe	8	3.8%
5	Japan	Asia	8	3.8%
6	Greece	Europe	7	3.3%
7	Ireland	Europe	7	3.3%
8	Canada	North America	6	2.8%
9	Argentina	South America	5	2.4%
10	Switzerland	Europe	5	2.4%
Total			212	

(b) 2022–2024

#	Country	Continent	count	%
1	USA	North America	1877	42.4%
2	China	Asia	639	14.4%
3	Germany	Europe	348	7.9%
4	UK	Europe	315	7.1%
5	Italy	Europe	299	6.8%
6	Australia	Australia	286	6.5%
7	India	Asia	252	5.7%
8	South Korea	Asia	143	3.2%
9	Canada	North America	138	3.1%
10	Singapore	Asia	126	2.8%
Total			4423	

3.5 Most relevant authors

From 2022–2024 (Table 4(b)), there was a notable shift in the leading scholars on GenAI. While all top 10 contributors in the period 2012–2022 (Table 4(b)) came from the USA, 2022–2024 saw a significant pivot towards Asia. China particularly emerged as the leading scholarly voice on GenAI. This shift indicates the rising influence of Asian researchers in GenAI.

Table 3: Most relevant sources

(a) 2012–2022

Source	**count**
CEUR Workshop Proceedings	8
Conference on Human Factors in Computing Systems – Proceedings	5
Lecture Notes in Computer Science[a]	5
ACM International Conference Proceeding Series	4
International Conference on Intelligent User Interfaces, Proceedings IUI	3
Proceedings of the 36th AAAI Conference on Artificial Intelligence, AAAI 2022	2
Proceedings of the National Academy of Sciences of the United States of America	2
2012 IEEE Congress on Evolutionary Computation, CEC 2012	1
2022 IEEE Congress on Evolutionary Computation, CEC 2022 – Conference Proceedings	1
35th AAAI Conference on Artificial Intelligence, AAAI 2021	1

[a] including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics

(b) 2022–2024

Source	**count**
Cureus Journal of Medical Science	56
CEUR Workshop Proceedings	55
Lecture Notes in Computer Science[a]	50
Proceedings of the Annual Meeting of the Association for Computational Linguistics	41
ACM International Conference Proceeding Series	32
Annals of Biomedical Engineering	19
Conference on Human Factors in Computing Systems – Proceedings	16
JMIR Medical Education	16
IEEE Access	13
Journal of Medical Internet Research	13

[a] including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics

3.6 Top Affiliations

Between 2012–2024, the affiliations of leading contributors also underwent a notable shift. Initially (Table 5(a)), the USA dominated, reflecting its strong research infrastructure. However, from 2022–2024 (Table 5(b)), a significant diversification occurred, with a broader international representation emerging. This period saw the rise of institutions from the United Arab Emirates (UAE), Singapore, Australia, Poland, and the UK, among others.

3.7 Country collaboration

There was hardly any international collaboration on GenAI during the first 11-year period (Figure 3(a)), with only one discernible partnership between the USA and Argentina. This con-

Table 4: Most relevant authors

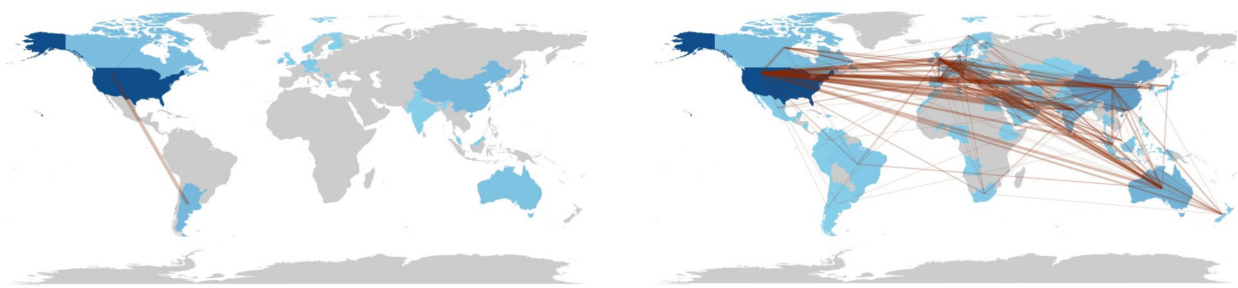
(a) 2012–2022

Author	Country	count
Houde S	USA	7
Muller M	USA	7
Agarwal M	USA	6
Talamadupula K	USA	6
Weisz Jd	USA	6
Breazeal C	USA	5
Martinez F	USA	5
Richards J	USA	5
Ali S	USA	4
Ross Si	USA	4
Total		55

(b) 2022–2024

Author	Country	count
Chen J	China	13
Kim J	Korea	11
Li H	USA	11
Li Y	China	11
Liu H	China	11
Liu J	China	10
Seth I	Australia	10
Wang X	China	9
Wang Y	China	8
Zhang Y	USA	8
Total		102

trasts sharply with the surge in global collaboration from 2022 onward (Figure 3(b)), spanning nearly every continent.



(a) 2012–2022 (b) 2022–2024

Figure 3: Country collaboration

Within the past year, GenAI has markedly enhanced global collaboration, establishing itself as a pivotal platform and catalyst across various disciplines. Its broad appeal, as seen in its application across diverse research fields in Section 3.10, shows GenAI's role in fostering transdisciplinary integration. The integration has enabled scholars from diverse fields to pool their expertise and perspectives, thereby enriching the collaborative efforts.

GenAI platforms such as ChatGPT, Google's Bard, and Microsoft's Copilot have been designed with user-friendliness in mind, reducing the need for specialist technical expertise that was once necessary for engaging with advanced AI tools as seen in the period 2012–2022. This approachability has significantly contributed to their widespread adoption, allowing a broader range of users from various backgrounds to utilise these platforms effectively. By lowering the

Table 5: Top affiliations

(a) 2012–2022

Affiliation	**Country**	**count**
Facebook AI Research	USA	6
Hefei University of Technology	China	6
Massachusetts Institute of Technology	USA	6
IBM Research AI	USA	5
Swiss Federal Institute of Technology (ETH Zurich)	Switzerland	5
University of Tsukuba	Japan	5
Universiti Malaysia Sabah	Malaysia	4
University of Illinois	USA	4
Kansas State University	USA	3
Shanghai Jiao Tong University	China	3
Total		47

(b) 2022–2024

Affiliation	**Country**	**count**
New York University, Abu Dhabi	UAE	41
University of Southern California	USA	36
National University of Singapore	Singapore	33
Icahn School of Medicine at Mount Sinai	USA	32
Monash University	Australia	30
University of California	USA	29
University of North Texas	USA	29
Wrocław University of Science and Technology	Poland	24
Mayo Clinic	USA	23
University of Cambridge	UK	23
Total		300

barrier to entry, these GenAI platforms have democratised access to advanced AI capabilities, facilitating a more inclusive environment for users worldwide including those from marginalised communities who often face barriers due to the digital divide. GenAI therefore offers opportunities for greater participation and representation in AI-driven advancements.

Their accessibility also ensures that individuals across different technical proficiencies can participate, further promoting an inclusive environment conducive to collaboration. This ease of access is a key factor driving GenAI's popularity as a collaborative tool.

Moreover, the rise of GenAI mirrors a broader shift in the research and academic culture towards openness and collective problem-solving. This paradigm shift acknowledges the complexity of contemporary challenges, which often demand efforts from more than one discipline, a process seamlessly facilitated by GenAI. The network effects triggered by GenAI's rapidly expanding user base further increase its value. As more scholars, individuals and institutions engage with GenAI platforms, the resultant growth not only enhances GenAI's usefulness but also fosters a virtuous cycle of increased scholarly adoption and collaboration.

3.8 Top 10 cited documents

The top ten papers from both periods (Tables 6 and 7) illustrate a shift from the ethical concerns and technical proficiency in the use of GenAI to a large scale usage of GenAI particularly in the medical and education fields.

Table 6: Top 10 cited documents 2012–2022

Source	**Publication**	**TC**	**Summary**
Rives et al. (2021)	Proceedings of the National Academy of Sciences of the United States of America	504	This paper investigated the use of unsupervised learning in AI to train a deep contextual LLM, leading to breakthroughs in biological data interpretation. The study demonstrated how the model's representations hold key biological insights from sequence data, offering a predictive edge in mutational effects and protein structure.
Gupta et al. (2017)	Molecular Informatics	285	This research presented a novel chemogenomic approach using generative recurrent neural networks (RNNs) for drug design, bypassing the need for extensive compound libraries. It highlighted the method's precision and adaptability, particularly in low-data scenarios for drug discovery.
Mirsky and Lee (2021)	ACM Computing Surveys	138	This article explored the ethical concerns of deepfake technology. It detailed the creation and detection of deepfakes, the progression of the technology, and the need for further research to bolster defence mechanisms against its misuse.
Williams et al. (2019)	Conference on Human Factors in Computing Systems – Proceedings	79	This study developed Popbots, an AI educational platform for preschoolers. It found that early AI education could significantly shape children's understanding of AI, with varied perceptions based on their age and learning performance.
Weisz et al. (2021)	International Conference on Intelligent User Interfaces, Proceedings IUI	33	This paper examined the application of unsupervised neural machine translation for code generation. It assessed software engineers' tolerance for imperfections in AI-generated code and discussed the potential for generative AI in software modernisation.
Sun et al. (2022)	International Conference on Intelligent User Interfaces, Proceedings IUI	24	This research interrogated explainable AI for generative models in software engineering. It proposed new explainable AI features and highlighted the importance of human-centered design in the technical development of explainable AI.
Zhang et al. (2022)	Conference on Human Factors in Computing Systems – Proceedings	24	This study designed StoryBuddy, an AI system for interactive storytelling. The system aims to balance the need for parent involvement with the goal of enhancing parent-child bonding while also accommodating parents' busy schedules.
Suh et al. (2021)	Conference on Human Factors in Computing Systems – Proceedings	23	This paper observed the role of AI in human collaboration during creative tasks. The key findings suggest AI can significantly influence social dynamics and creativity, offering insights for the future integration of AI in co-creative processes.
Wu et al. (2020)	Computers in Human Behaviour	20	This survey investigated perceptions of AI-generated content across different cultures. It found contrasting views between American and Chinese subjects regarding AI's role in artistic creation, enriching the dialogue on the impact of AI in the arts.

[Continued ...]

Table 6: […continued]

Source	**Publication**	**TC**	**Summary**
Ali et al. (2021)	Conference on Human Factors in Computing Systems – Proceedings	17	This study proposed a learning trajectory for middle schoolers about GenAI. It emphasised the importance of educating the young on ethical aspects of AI, based on findings from interactive workshops.

Table 7: Top 10 cited documents 2022–2024

Source	**Publication**	**TC**	**Summary**
Y. K. Dwivedi et al. (2023)	International Journal of Information Management	226	This study scrutinised the integration of GenAI in streamlining information management processes, illustrating its pivotal role in enhancing data interpretation and decision-making within organisations.
Gilson et al. (2023)	JMIR Medical Education	205	The research investigated the deployment of GenAI in medical education, revealing innovative teaching tools that leverage AI to create dynamic learning materials and simulations, significantly impacting educational outcomes.
Rudolph et al. (2023)	Journal of Applied Learning & Teaching	123	The study highlighted the use of GenAI in crafting customised learning experiences, focusing on the practical application of AI-generated content to enhance teaching methodologies.
Tlili et al. (2023)	Smart Learning Environments	112	This article presented the application of generative AI in smart learning environments, demonstrating how it can tailor educational content to individual learner profiles, thereby revolutionising traditional educational paradigms.
Ayers et al. (2023)	JAMA Internal Medicine	109	The study explored GenAI's role in internal medicine, particularly in developing predictive models for patient care, which has led to more precise and personalised treatment plans.
Pavlik (2023)	Journal of Mass Communication Education	108	This paper examined the impact of GenAI on mass communication education, emphasising how AI tools can generate diverse media content, thereby enriching the learning experience for students.
Cotton et al. (2023)	Innovations in Education and Teaching International	103	The research focused on the GenAI's contribution to educational innovation, particularly its capability to produce diverse and inclusive educational materials that resonate with a global student body.
Cascella et al. (2023)	Journal of Medical Systems	101	This study investigated the incorporation of GenAI in medical systems, noting its potential to revolutionise patient diagnostics and treatment pathways through advanced AI-generated models.
Salvagno et al. (2023)	Critical Care	98	The paper highlighted how GenAI is being utilised to create simulation models for critical care training, offering realistic scenarios that are instrumental in preparing healthcare professionals for emergency situations.
Alkaissi and McFarlane (2023)	Cureus Journal of Medical Science	87	This study outlined the use of GenAI in medical science education, underlining its role in generating complex biological models that aid in both teaching and research.

3.9 GenAI Usage and Opportunities

A thematic analysis using an open coding approach was conducted for the usage and opportunities, as well as the concerns, between the two periods (Braun & Clarke, 2006). Initially, all the abstracts in the period 2012–2024 were manually analysed to derive codes, and from the codes, overarching themes, and then finally constructing a narrative to describe the themes that emerged. Atlas.ti was used for this process. ChatGPT was then used to compare its thematic analysis with the manual analysis which proved sufficiently similar and revealed a few more codes. ChatGPT GPT-4 version was particularly useful for the second period 2022–2024 with 1828 abstracts.

Before the emergence of ChatGPT (Table 8), GenAI was prominently engaged in the arts and design sector due to its creative capabilities. In education, GenAI was leveraged to enrich learning experiences, frequently through robotic intermediaries. GenAI had already begun integrating into a few other disciplines, illustrating its potential even before ChatGPT.

Table 8: Usage of GenAI prior to ChatGPT (2012–2022)

Discipline	**Code (number)**	**Brief integrative narrative**
Computer Science (30)	Algorithm (2) Computing (5) Software (10) System (12) Simulation (1)	GenAI was used in system development, software engineering, and algorithm design. It also played a role in simulation and computing, reflecting its foundational impact on technological advancements. An example includes the novel use of a modified Pareto Differential Evolution (PDE) algorithm for bi-objective optimisation of the weights in an Artificial Neural Network (ANN) controller. This marked a significant development in the field, which previously focused only on single-objective optimisation.
Art and Design (42)	Design (19) Art (9) Creative (10) Aesthetic (1) Visual (3)	GenAI played a pivotal role in the art and design sector, particularly in creative projects involving real-time strategy games. This indicated GenAI's emerging role in enhancing creativity and aesthetic judgment. Examples included creating simulations and collaboration in the creation of classical Japanese poetry.
Environmental Science (2)	Environment (1) Sustainable (1)	While less prominent, GenAI used top-down strategy mechanisms like steering development processes and addressing misinformation. For instance, the use of interactive learning environments and digital literacy programs to combat deepfakes and social media misinformation demonstrated how to refine ideas and ensure alignment with desired outcomes.
Healthcare (4)	Drug (4)	GenAI models provided innovative approaches to chemogenomics and de novo drug design. They enabled researchers to focus on specific regions of the chemical space, as demonstrated by exploring the chemical space and generating new molecules. This assisted in the discovery of new drugs. GenAI was also used to maximise the use of limited data in making new drug discoveries.
Education (32)	Learning (25) Education (6) Teaching (1)	GenAI also played a role in education, especially in enhancing learning experiences. One notable example involved fine-tuning Recurrent Neural Network (RNN) predictions for specific molecular targets using transfer learning. Additionally, the introduction of the NAO humanoid robot in elementary schools offered a unique perspective on learning. Here, students engaged in collaborative discussions, questioning, and reflective writing activities centered around the robot.

[Continued ...]

Table 8: [...continued]

Discipline	Code (number)	Brief integrative narrative
Robotics (2)	Robot (1) Humanoid (1)	In robotics, GenAI contributed to the development of sociable robots, which are increasingly being used as interfaces for various services. Notably, children born after 2010, the "AI Generation" became familiar with social robotic interfaces, influencing their mental development. Some children percieved the social robots as more intelligent and/or less intelligent than humans, and others simply viewed them as toys.

Post-ChatGPT (Table 9), there has been a substantial surge in the usage and integration of GenAI, marking a new era of technological adoption. The scholarly discourse has evolved past the previous ethical concerns surrounding GenAI, embracing its integration across various disciplines. Education has particularly been at the forefront of using GenAI, significantly enhancing the learning experiences. Similarly, healthcare has expanded its use of GenAI, enriching medical science curricula and improving patient outcomes. GenAI has also facilitated the development of autonomous robots equipped with communicative capabilities.

Table 9: Usage of GenAI post ChatGPT (2022–2024)

Discipline	Code (number)	Brief integrative narrative
Education (1208)	Learning (543) Education (495) Teaching (170)	GenAI has revolutionised education, significantly enhancing learning and teaching methodologies. Notably, the integration of LLMs into educational systems. These LLMs are being used to develop personalised study plans, innovative teaching methods, and more interactive learning materials. For instance, ensemble neural models have been proposed to generate probabilities from different pre-trained LLMs thereby offering more tailored and effective educational experiences.
Computer Science (83)	Algorithm (44) Computing (39)	LLMs have significantly advanced NLP, setting new performance standards, with ChatGPT having the most profound impact on GenAI. These LLMs are now fine-tuned using advanced ML techniques capable of generating fully autonomous NLP conversations, demonstrating the rapid progress and growing capabilities in AI and computing.
Psychology (108)	Behavioral (20) Cognitive (55) Mental (33)	GenAI is now being used in psychology to understand behavioral and cognitive dynamics, to analyse and predict human behavior and mental processes, thereby offering deeper insights into the human psyche. For example, studies on chatbot acceptance show how instrumental and non-instrumental gratifications, along with social norms, significantly influence user interactions with AI, revealing the intricate relationship between technology and human psychology.
Communication (685)	Information (460) Media (114) Communication (111)	While GenAI-generated content enhances information dissemination, it also poses risks of misinformation and factual inaccuracies. A critical examination of these issues, including algorithmic bias, privacy concerns, and the impact of GenAI on media and communication, reveals the need for ethical considerations and responsible use of technology in communication.

[Continued ...]

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Table 9: […continued]

Discipline	Code (number)	Brief integrative narrative
Healthcare (694)	Medical (284) Clinical (238) Health (172)	GenAI has also led to transformative changes in healthcare. LLMs have revolutionised medical curriculum development, teaching methodologies, and student assessments. These models hold promise for creating more effective and personalised medical training and patient care strategies. Their application in clinical settings is also expanding, with the potential to significantly improve patient outcomes and healthcare services.
Robotics (38)	Autonomous (25) Robotics (12) Humanoid (1)	In robotics, GenAI is enhancing the development of autonomous systems and humanoid robots. Technologies like ChatGPT are demonstrating the ability to autonomously generate natural language, which is vital for human-robot interaction. The ongoing research in this field is focused on optimising these interactions to be more ethical and to minimise harm, reflecting the growing sophistication and ethical considerations in the use of GenAI in robotics.

3.10 GenAI Challenges and Concerns

Prior to ChatGPT (table 10), the concerns about GenAI included inaccuracies and ethical issues stemming from biased training data. These inaccuracies, ethical concerns and societal impacts remain the dominant challenge with GenAI post-ChatGPT (Table 11) despite the widespread usage. This shows that scholars in the GenAI community recognised these challenges early on and raised the alarm.

Table 10: Challenges with GenAI pre-ChatGPT (2012–2022)

Discipline	Code (number)	Brief integrative narrative
Technical Challenges (10)	Performance (5) Errors (3) Accuracy (1) Scalability (1)	The most noted challenge was with the performance of GenAI models, particularly in ensuring their efficient and effective operation. There were other challenges related to errors from inaccuracies and mistakes in GenAI-generated outputs. These concerns about accuracy further pointed to the challenges in maintaining precision in the outputs. Scalability problems reflected the difficulties in expanding GenAI systems to handle larger or more complex tasks without a loss in performance or efficiency.
Ethical Concerns (3)	Bias (2) Privacy (1)	Bias was identified twice, highlighting the problem of GenAI systems potentially perpetuating or even amplifying existing societal biases. Privacy concerns were also noted, reflecting the complexities involved in responsibly handling personal data within GenAI systems.
Societal impact (2)	Society (2)	The two instances pointed to broader implications for society around the impact of GenAI on social dynamics and human interactions, raising questions about the long-term effects of increasingly relying on GenAI systems in various aspects of life. This is particularly relevant where decision-making, both at individual and organisational levels, becomes heavily dependent on GenAI recommendations. This dependency might reduce human engagement in critical thinking and problem-solving, potentially leading to an erosion of these skills. Another concern relates to shifts in labour markets, and the moral implication in areas such as law enforcement or healthcare.

Table 11: Challenges with GenAI post-ChatGPT (2022–2024)

Discipline	**Code (number)**	**Brief integrative narrative**
Technical challenges (791)	Performance (384) Accuracy (329) Complexity (39) Error (33) Scalability (6)	There is still a significant challenge with the performance of GenAI systems. For example, one abstract described the ongoing efforts to improve real-time processing capabilities in autonomous vehicles. The accuracy of predictions remains a crucial focus with research going into refining LLMs to better understand and generate human-like text. The issues of complexity and scalability further highlighted the ongoing work to simplify GenAI models for broader applications, particularly in fields such as healthcare, where complex data requires simplified yet effective analysis.
Ethical concerns (186)	Privacy (88) Bias (71) Consent (14) Moral (13)	There is a growing emphasis on privacy, especially in contexts where GenAI is used for personal data analysis, urging for enhanced data protection measures. Bias continues to be a critical ethical challenge, with some studies indicating that GenAI-driven hiring tools perpetuate gender bias. The need for informed consent and ethical considerations,such as the use of facial recognition technology when used in public spaces, is important.
Societal impact (169)	Society (147) Employment (9) Human Interaction (8) Dependency (4) Social Impact (1)	The major concern is the way GenAI is transforming society particularly traditional education systems, promoting personalised learning while raising questions about reduced human interaction. There are envisaged and real employment changes especially with job displacement, changed human interaction as a result of changes in social behaviour, and feared societal dependency on GenAI due to the increased AI integration.
Legal issues (163)	Legal (76) Law (37) Regulation (34) Compliance (16)	There is a need for new regulations in applications that use GenAI such as drone technology when it is used in surveillance. The implications have effects on compliance with the law and the associated regulations.
Data issues (36)	Data Privacy (20) Data Security (12) Data Quality (3) Data Availability (1)	Data privacy and security are highlighted for examples of research to secure GenAI systems against data breaches. Data quality and availability were illustrated by studies on the impact of poor data quality on GenAI decision-making in critical sectors like finance.

3.11 Sentiments before and after ChatGPT

From 2012–2022 (Table 12), the sentiment towards GenAI was predominantly positive, reflecting optimism in sectors like healthcare, where GenAI's accuracy in disease identification promised to revolutionise diagnostics. However, concerns about privacy and ethical implications of GenAI in surveillance were noted, emphasising the need for thoughtful regulation. Years 2022–2024 witnessed a huge surge in positive sentiment towards GenAI, particularly for its applications in various fields, signaling its potential to address pressing global challenges. Yet, the rising optimism has not been without reservations, particularly around the impact of GenAI on job automation, highlighting the need for a balanced approach in embracing GenAI advancements.

https://doi.org/10.18489/sacj.v37i1.17890

Table 12: Sentiments before and after ChatGPT

Period	Sentiment	#	Brief narrative
2012 – 2022	Positive	46	The positive sentiment predominantly leans towards optimism and enthusiasm. An example is the breakthrough in AI-driven healthcare solutions where GenAI algorithms successfully identified diseases with greater accuracy than traditional methods. Such advancements demonstrate the potential of GenAI to revolutionise medical diagnostics and treatment, eliciting a sense of hope and excitement for the future of healthcare.
	Neutral	0	
	Negative	10	There were concerns and apprehensions about the impact of GenAI for example around the ethical implications of GenAI in surveillance, where fears about privacy invasion and misuse of GenAI for intrusive monitoring were highlighted. These concerns highlighted the need for careful consideration and regulation in the deployment of AI technologies to protect individual rights and freedoms.
2022 – 2024	Positive	1589	There is now an overwhelming positivity especially around the groundbreaking GenAI applications. For example, in environmental science, GenAI models actively predict climate change patterns, offering vital insights for mitigating environmental risks. These examples foster a sense of hope and anticipation for the potential of GenAI to address some of the world's most pressing challenges.
	Neutral	12	While limited the neutral sentiments indicate areas where the impact of GenAI is still uncertain or where its implications are yet to be fully understood. For example the use of GenAI in artistic endeavors, where there is a mix of curiosity and skepticism about the role of GenAI in creative processes.
	Negative	227	There are nonetheless still major concerns and reservations about GenAI and AI. A notable example was over GenAI in job automation, where there is apprehension about potential job losses and the displacement of human labour. These concerns highlight the complexities and ethical dilemmas that GenAI introduces, prompting a call for more stringent regulations and ethical guidelines.

4 DISCUSSION OF FINDINGS

In order to offer a balanced discussion of the key findings, we adopted a post-digital lens mainly because it allows for a critical examination of the seamless integration of digital technologies into daily life, highlighting the intertwined nature of digital and non-digital realms and the cultural, social, and economic implications of this ubiquity (Cramer, 2015).

4.1 More Rapid Technological Evolutions and their Impacts

The rapid integration of ChatGPT and similar GenAI technologies marks a significant evolution in AI capabilities. This evolution is characterised by the sophisticated development of transformer architectures, pre-training processes, and fine-tuning methodologies. These technical advancements have revolutionised sectors like healthcare, education, and software engineering, demonstrating the potential for significant innovations and efficiency enhancements (Y. K. Dwivedi et al., 2023). This technological leap signifies a transformative change in how problem-solving, knowledge creation, and service delivery are approached across different sectors. The leap introduces a new era of enhanced productivity and innovation, where

GenAI's capabilities can be harnessed to tackle complex challenges more effectively. For example, a 2024 McKinsey survey shows that GenAI adoption has more than doubled in the previous five years, and there is an increase in GenAI investment (McKinsey & Company, 2024). For practitioners and policymakers, this new era points to the urgency of adapting to rapidly changing technologies. For educators and healthcare professionals, GenAI offers tools for unprecedented advancements in personalised education and patient care. Ultimately, GenAI impacts society at large, promising to elevate the quality of life through improved services and innovations.

4.2 Transdisciplinary Integration

The post-ChatGPT era has facilitated greater disciplinary collaboration regardless of region, enabling the integration of GenAI into diverse fields. This unprecedented collaboration is driven by the data-rich insights that GenAI platforms provide, which offer a deeper, evidence-based understanding of complex phenomena across domains. These data-driven capabilities empower researchers to not only test existing theories but also extend them into areas previously unexplored, thereby facilitating unique innovations and the creation of new theories and frameworks (Klein-Avraham et al., 2024). For example, researchers in Information Systems (IS) and Computer Science can use GenAI to provide unique opportunities to refine and adapt their core theories to address challenges in other domains, such as healthcare, education, and the arts (Twinomurinzi et al., 2022). This dynamic interaction allows for the tailoring of theoretical constructs to suit the specific needs and contexts of other disciplines (Y. K. Dwivedi et al., 2023).

Moreover, the insights generated through GenAI encourage the emergence of entirely new disciplines that reflect the convergence of traditional fields. For example, the integration of computational methodologies with social sciences or the arts leads to the development of hybrid fields such as computational sociology or AI-driven creative design (Davidson, 2024; Tan & Luhrs, 2024). This transdisciplinary potential not only bridges existing gaps between disciplines but also creates a fertile ground for the development of more holistic approaches to solving complex, global challenges.

4.3 Ethics Reflections

The rapid integration of GenAI has brought ethical considerations to the forefront, particularly concerning privacy, bias, and the equitable distribution of its benefits. These dilemmas challenge existing social and technical frameworks, necessitating careful navigation to ensure fairness and accountability (Xivuri & Twinomurinzi, 2022). For regulators and ethicists, this signals an urgent need to develop guidelines that promote the responsible and transparent use of GenAI (Cherner et al., 2024). For the general public, GenAI represents a dual-edged sword: it offers significant advancements while also posing risks to privacy, equity, and access to opportunity. Balancing these concerns is critical to ensuring that GenAI's transformative potential benefits society as a whole and does not increase the digital divide.

4.4 Legal Implications and Societal Adjustments

The integration of GenAI into everyday life presents new and intricate legal, societal, and regulatory complexities. GenAI technologies challenge the boundaries of existing societal norms and legal frameworks, exposing significant gaps in their ability to address the rapidly evolving nature of emerging technologies. This means that legal experts and policymakers need to learn to innovate within legal structures to safeguard individual and collective rights without limiting technological progress.

The transformative potential of GenAI extends to the creation of entirely new disciplines and the jobs required within them. As these emerging fields take shape, educational institutions will need to rise to the challenge of designing entirely new curricula that equip learners with the skills necessary for the future world of work. This includes new programmes that merge technical expertise with ethical, social, and creative insights, ensuring future-fit skills.

For society, embracing a new world of work means rethinking traditional employment structures and adopting more flexible, adaptive approaches to workforce development. Policymakers should consider more experimental and dynamic methods in crafting policies that anticipate and respond to the fluid realities of a GenAI- and AI-driven economy. This could include policies that support continuous learning, universal access to reskilling opportunities, and equitable participation in the benefits of GenAI. The same applies to the legal domain which needs to become more reflexive and adaptive, developing mechanisms that not only regulate GenAI but also encourage its responsible and equitable deployment without stifling innovation.

The deeper societal issue is what it means to be human in an era shaped by these technologies that supercede human intelligence in many ways, and the role of human values such as creativity, spirituality, empathy, and connection.

4.5 Limitations

The study is limited in its usage of only two academic databases without taking into account the vast non-academic literature, nor other GenAI platforms that have emerged since ChatGPT. The limited scope is partially a result of the tools available to conduct bibliometric analyses.

5 CONCLUSIONS

The study investigated the scholarly discourse on GenAI since before ChatGPT and after ChatGPT using a bibliometric review and thematic analysis. We sought to interrogate how prevalent patterns of GenAI usage have manifested in scholarly discourse and the primary drivers behind the adoption of these technologies. The reality of the transition from one million "early adopters" in five days to an "early majority" of 100 million users within two months indicates that ChatGPT ushered an inflection point in society (Altman, 2022).

The key factor that drives the scholarly discourse of GenAI is transdisciplinary collaboration across regions, disciplines and sectors. Transdisciplinarity is about building bridges between disciplines that have different notions of reality, which bridges themselves become a reality of their own with a new set of language to make sense of the bridge (Klein, 2004). GenAI has managed to navigate the challenges of transdisciplinarity by addressing key limitations inherent in traditional, reductionist approaches. The traditional approaches often prioritise rational logic over relational or qualitative understanding, overlooking the relatedness of disciplines and the role of intuition in knowledge creation (Max-Neef, 2005). In contrast, GenAI fosters a more integrated perspective, bridging the gaps caused by the uni-disciplinary focus prevalent in most educational institutions, particularly at the undergraduate level, and the compartmentalisation of funding into narrowly defined tasks and sub-disciplines (Max-Neef, 2005). While current universities guard disciplinary silos and primarily engage in interdisciplinary collaboration, GenAI opens ways for truly transdisciplinary innovation.

While GenAI has democratised access to advanced AI capabilities, the digital divide continues to pose a significant challenge. Certain demographics and regions, especially in Africa, have unequal access to technology, infrastructure, and digital literacy. These disparities risk exacerbating existing inequalities, leaving marginalised communities further behind.

The rapid adoption of GenAI has also brought ethical dilemmas to the forefront, particularly around issues such as privacy, bias, and equitable access. Ethical lapses in GenAI development and deployment could deepen societal mistrust and perpetuate existing inequalities. A proactive approach is needed to embed ethical considerations into the design, training, and deployment of GenAI models. This includes promoting transparency, accountability, and inclusivity at every stage of development.

The absence of robust legal and regulatory frameworks for GenAI presents significant risks. Without clear guidelines, the deployment of GenAI could lead to misuse, data breaches, and violations of individual rights. Legal experts and policymakers must act swiftly to develop adaptive and reflexive regulations that safeguard privacy, ensure accountability, and promote equitable use. Such frameworks should encourage innovation while protecting societal interests, ensuring that GenAI evolves in a manner that benefits all.

This paper makes a contribution to knowledge and offers some implications for academia, researchers, practice and policy. In IS, GenAI provides a basis for extending existing IS theories using data-driven insights. GenAI allows for the creation of hybrid theoretical frameworks that incorporate both technical efficiency and social implications. In Computer Science, GenAI demands a rethinking of traditional frameworks to include human feedback, contextual accuracy, and ethical AI design. The advancements in transformer models and reasoning capabilities prompt theoretical explorations into designing adaptive systems that balance technical innovation with accountability.

Educators face the challenge of preparing learners for a world reshaped by GenAI. This requires the design of new curricula that integrate technical, ethical, and creative dimensions of

GenAI, equipping students with the skills to navigate hybrid roles across emerging fields and disciplines. Educational institutions must prioritise disciplinary collaboration, offering programmes that blend technical expertise with insights from the humanities and social sciences. Additionally, there is a pressing need to foster lifelong learning by embedding AI literacy and digital skills training across all levels of education. Such efforts will ensure that students are not only proficient in GenAI and AI technologies but also prepared to address their societal implications.

Practitioners will similarly need to adapt to the evolving demands of a GenAI-driven world by embracing continuous learning and innovation. Workforce development initiatives should focus on reskilling and upskilling to align with the hybrid roles created by GenAI.

Policymakers will be required to navigate the complexities of integrating GenAI into society by developing adaptive and reflexive regulatory frameworks. These regulations should address critical issues such as privacy, bias, accountability, and equitable use, while encouraging an environment that supports innovation and humanity. Closing the digital divide is another pressing priority, requiring investments in infrastructure, digital literacy, and development policies. Policymakers should also adopt experimental approaches, such as sandbox regulations, to allow for dynamic and iterative responses to the challenges posed by GenAI.

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