

Original Research Article

## Research hotspots and frontiers of digital literacy in the generative AI era: A CiteSpace-Based analysis of web of science literature

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**Abstract:** This study uses CiteSpace to conduct a scientific econometric analysis of the research literature on digital literacy in the generative AI era in the core database of Web of Science. The results show that this field mainly focuses on educational applications, with core themes including higher education, AI literacy and critical thinking. Outbreak detection analysis indicates that the research direction has developed in a dual trajectory from the conceptual expansion in 2023 to after 2024, covering not only technological frontiers such as prompt engineering but also critical reflection fields like critical literacy. The research findings emphasize the need to establish an integrated framework that combines the application of technology with ethical reflection, and call for continuous strengthening of interdisciplinary cooperation.

**Keywords:** generative artificial intelligence; digital literacy; research hotspots; frontier exploration

## 1. Introduction

The rapid popularization of artificial intelligence (GenAI) technology has led to a paradigm shift in the requirements for digital literacy in various fields such as education, careers, and society<sup>[1]</sup>. This technological wave, while enhancing the efficiency of information creation and acquisition, also poses profound challenges to individual cognition and social norms. The traditional framework of digital literacy focuses on the retrieval, evaluation and utilization of information. However, in the GenAI era, the connotation of digital literacy urgently needs to expand to new dimensions such as interaction, collaboration and even critical reflection with intelligent systems. This transformation highlights the urgency of redefining digital capabilities, which not only encompass traditional technical skills but also ethical awareness, critical assessment, and adaptive application of AI systems<sup>[2]</sup>. At present, academic research on this topic mostly focuses on qualitative exploration of educational scenarios or analysis of literacy demands under the application of a single technology. There is a lack of systematic sorting out of research hotspots worldwide and quantitative detection of cutting-edge trends, especially bibliometric research based on the Web of Science (WoS) core collection. In view of this, this study takes the literature related to generative AI and digital literacy in the WoS database as the research object, and uses the CiteSpace visualization tool to identify the core research topics in the field and track the cutting-edge evolution path through keyword co-occurrence, clustering and emergent word analysis. With the aim of providing data support and theoretical references for constructing a digital literacy framework suitable for the generative AI era and clarifying subsequent research directions.

## 2. Literature review

The rapid development of Generative AI has significantly enhanced the urgency and complexity of Digital Literacy research. With the extensive penetration of generative AI technologies such as large language models (LLMs), the effective assessment, utilization, and ethical participation of individuals in the AI-driven information ecosystem has become a core concern in interdisciplinary research. Existing research reveals that the connotation of digital literacy has transcended the traditional information technology

operation ability and expanded to a comprehensive construct covering multiple dimensions such as critical understanding of AI systems, technical application ability, ethical awareness, and social impact cognition. Empirical research provides strong support for this<sup>[3]</sup>. For instance, a survey and analysis of college students have shown that four key sub-dimensions of digital literacy - critical understanding, identification of the social impact of AI, technology utilization, and ethical behavior - significantly influence their perception of the usefulness and ease of use of AI technology<sup>[4]</sup>. Among them, the ability to utilize technology has been confirmed as the most predictive factor. This discovery profoundly confirms that in the era of generative AI<sup>[5]</sup>, the construction of a digital literacy framework urgently needs to deeply integrate the dual orientation of technical practical ability and ethical reflection awareness.

### 3. Research methods

To ensure the international cutting-edge nature and representativeness of the research, the data of this study is sourced from the authoritative Web of Science (WoS) core collection database. Based on the research topic, the search formula is constructed as: TS=("generative AI") AND ("digital literacy"), aiming to accurately capture the core literature that simultaneously explores generative artificial intelligence technology and digital literacy. To further enhance the relevance and quality of the analyzed samples, the following screening criteria have been set: The publication time of the literature is limited to all years to cover the key stages from the infancy to the rapid development of this field; The type of literature is limited to academic papers (Article) to ensure the completeness and depth of the content. The language is limited to English.

## 4. Research hotspots

### 4.1. Knowledge structure and static topic distribution

To explore the research hotspots in the field of digital literacy in the era of generative AI, this study first conducted keyword co-occurrence (**Figure 1**) and cluster analysis (**Figure 2**). Through in-depth interpretation of the clustering graph, the core research topic framework in this field can be identified. The graph automatically generated multiple highly correlated clusters, among which the most representative ones include #1 Higher Education, #2 Digital Literacy, #3 Critical Thinking, #4 Educational Technology, and #0 Sustainable Education, etc. These clusters do not exist in isolation but are interwoven through dense connections, forming a tight network centered on "educational applications". In particular, the close coupling of the three major clusters #1 higher education, #2 digital literacy, and #4 educational technology clearly indicates that the current research focus is highly concentrated on the core issue of how to integrate artificial intelligence literacy and reshape the traditional digital literacy framework in the context of higher education.

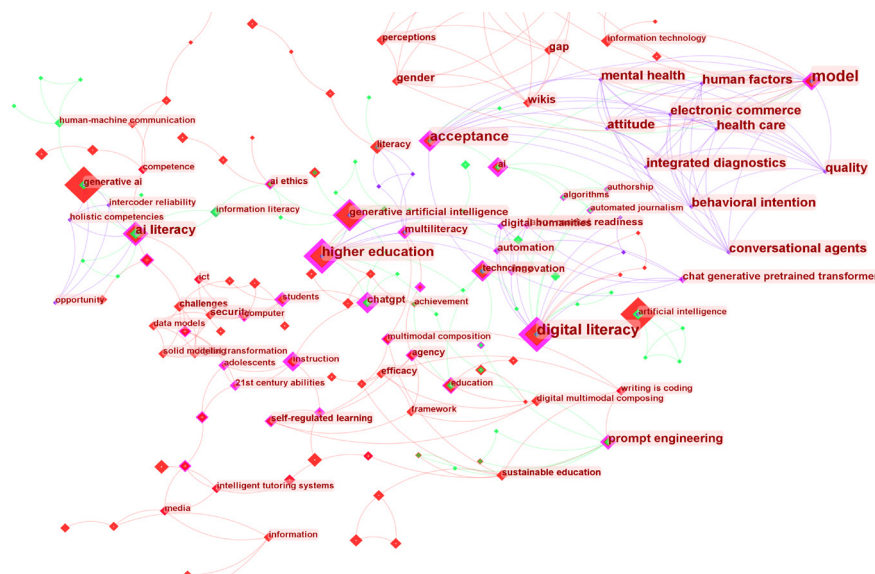


Figure 1. Keyword contribution.

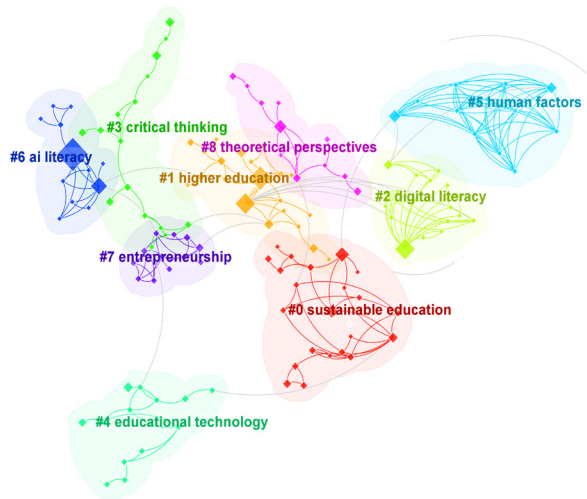


Figure 2. Keyword clustering.

4.2. Dynamic evolution and emerging focuses

To reveal the dynamic evolution trajectory of the research topic, this study further conducted a keyword emergent analysis (Figure 3), presenting the top 9 keywords with the highest emergent intensity, with a time span from 2023 to 2025. The analysis results clearly reveal the evolution path of the research frontier: In the early stage (2023), the sudden emergence of multiliteracy marked the beginning of the academic community to think about literacy issues from a more macroscopic and integrated perspective. Entering 2024, the research frontier has shown a remarkable feature of explosive diversification and deepening. On the one hand, key words closely related to technical practice have emerged intensively, including chatgpt, prompt engineering, and human-machine communication. This indicates that the research frontier has rapidly shifted from generalized theoretical discussions to empirical explorations of the application, interaction skills, and workflow of specific generative AI tools. On the other hand, topics related to critical reflection on the connotation of literacy have also emerged simultaneously, such as digital/media literacy, critical literacy and theoretical perspectives. digital/media literacy has the strongest emergent intensity, highlighting that in the context of generative AI, the boundary between traditional digital literacy and media literacy is increasingly blurred, and the urgent need for theoretical integration and critical reconstruction has become the most concerned focus. In 2024, the two themes of "technological application" and "critical reflection" simultaneously became the forefront, outlining that research in this field is moving towards a deepening development stage that emphasizes both instrumental rationality and value rationality.

Top 9 Keywords with the Strongest Citation Bursts

| Keywords                    | Year | Strength | Begin | End  | 2023 - 2025            |
|-----------------------------|------|----------|-------|------|------------------------|
| multiliteracy               | 2023 | 0.74     | 2023  | 2025 | <div><div></div></div> |
| digital/media literacy      | 2024 | 1.96     | 2024  | 2025 | <div><div></div></div> |
| chatgpt                     | 2024 | 1.55     | 2024  | 2025 | <div><div></div></div> |
| information literacy        | 2024 | 1.47     | 2024  | 2025 | <div><div></div></div> |
| ai literacy                 | 2023 | 1.24     | 2024  | 2025 | <div><div></div></div> |
| human-machine communication | 2024 | 0.98     | 2024  | 2025 | <div><div></div></div> |
| critical literacy           | 2024 | 0.98     | 2024  | 2025 | <div><div></div></div> |
| theoretical perspectives    | 2024 | 0.98     | 2024  | 2025 | <div><div></div></div> |
| prompt engineering          | 2024 | 0.84     | 2024  | 2025 | <div><div></div></div> |

Figure 3. Key words highlighted.

5. Conclusion

In this study, CiteSpace software was used to conduct a scientific econometric analysis of the research

literature on digital literacy in the era of generative artificial intelligence in the Web of Science core collection, and systematically explored the research hotspots and frontier trends in this field. The research hotspots present a prominent feature centered on educational applications. Cluster analysis identified core themes such as "Sustainable Education" (#0), "Higher Education" (#1), "Digital Literacy" (#2), "Critical Thinking" (#3), and "Educational Technology" (#4). This indicates that current research is highly focused on educational contexts, especially in higher education teaching practices, on how to integrate new dimensions such as AI literacy and critical thinking into the traditional digital literacy framework and pay attention to their long-term impact. The research frontier shows a dynamic trend of evolving from the analysis of the connotation of literacy to a dual-track system of specific practice and in-depth reflection. The analysis of emergent words shows that the frontier process can be divided into two stages: The expansion of the connotation of literacy represented by "multi-literacy reading" in 2023; Starting from 2024, the frontier has rapidly differentiated into two clear paths: One is the practical frontier oriented towards technical operations, such as "prompt engineering" and "human-computer interaction"; The second is to emphasize the critical frontier of value rationality, such as "critical literacy" and "theoretical perspective". This reveals that the field is shifting from a macroscopic discussion of "why" to a two-way in-depth exploration of "how" to effectively apply technology and "how" to critically examine technology ethically. The research, through the visualization of knowledge graphs, clearly outlines the knowledge structure and evolution context of this field, providing a macroscopic perspective for subsequent studies. However, this study only focused on English journal literature. In the future, more languages and publication types can be included, and more detailed content analysis can be conducted to deepen the understanding of specific teaching practices and policy-making. Overall, digital literacy research in the era of generative AI is a dynamic and increasingly complex interdisciplinary field, and its development urgently requires continuous dialogue and collaborative innovation among the education, technology, and ethics communities.

## Fundings

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