



Threats to Scientific Epistemology in the Digital Era: A Systematic Literature Review

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Abstract

This study examines the structural limitations and emerging threats to scientific knowledge in the digital era. While digital transformation enhances access to information, it simultaneously raises critical challenges regarding the production, validation, and authority of knowledge. This research employs a systematic literature review approach, analyzing scholarly articles published between 2020 and 2025. Data were collected from national academic journals and examined using content analysis and critical discourse analysis. The findings reveal that major limitations include digital inequality, the erosion of scientific authority, and ethical dilemmas in big data research. Furthermore, significant threats arise from the proliferation of misinformation and disinformation, the weakening of critical thinking due to algorithm-driven filter bubbles, the dominance of commercial technology platforms, and biases embedded in artificial intelligence systems. This study concludes that digitalization does not automatically strengthen scientific epistemology; instead, it may undermine it without robust regulatory and educational frameworks. The study recommends strengthening open science infrastructure, integrating digital and critical literacy into education systems, and developing policies to protect the knowledge ecosystem.

INTRODUCTION

The development of scientific knowledge in the digital era has undergone a significant paradigm shift, marked by the digitalization of knowledge production, distribution, and consumption (Giraldo et al., 2022; Magliacani & Sorrentino, 2021). The integration of information technology into scientific practices not only accelerates collaboration and the dissemination of research findings but also transforms the structure, authority, and validation of knowledge itself. While this transformation creates new opportunities for more inclusive and efficient scientific advancement, it simultaneously introduces structural limitations and substantive threats that may undermine the epistemological foundations of science (Pitriani et al., 2024; Ravetz, 2020; Saleh et al., 2025).

In the Indonesian context, the adoption of digital technologies in academia has accelerated significantly, particularly during and after the COVID-19 pandemic. This acceleration has led to increased reliance on digital platforms for learning,

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research, and scientific publication. However, such rapid development has not been fully accompanied by adequate infrastructure, regulatory frameworks, or sufficient levels of digital literacy and critical thinking (Ng, 2012; Setiawan, 2022). Consequently, several challenges have emerged, including digital inequality, the proliferation of misinformation presented as scientific knowledge, and the growing influence of commercial technology platforms in shaping the production and dissemination of knowledge.

From a theoretical perspective, these dynamics can be understood through the lens of paradigm shifts in scientific development, as proposed by Thomas Kuhn (Anand et al., 2020; Aryal, 2023; Li & Huang, 2019). The digital era can be considered a phase of revolutionary science, in which technology functions not merely as a tool but as an active agent that shapes how knowledge is produced, validated, and interpreted. Furthermore, the concept of Mode 2 Knowledge Production, introduced by Michael Gibbons, explains the transition toward a more transdisciplinary, context-driven, and socially distributed form of knowledge production an evolution that is significantly intensified by digitalization (Rotem & Shani, 2025).

At the same time, digitalization brings complex epistemological and methodological implications. The use of big data and computational approaches enables large-scale analysis but risks shifting the focus from causal explanation to mere correlation (Clavert, 2013; Martini, 2016; Tosi et al., 2024; Zhang et al., 2018). In addition, digital algorithms shape information consumption through filter bubbles and echo chambers, potentially limiting exposure to diverse perspectives and weakening critical thinking in the evaluation of scientific information.

Empirical studies indicate that threats to scientific knowledge in the digital era are increasingly evident. Misinformation and disinformation, often presented in forms resembling scientific content, can mislead the public and erode trust in science (Giraldo et al., 2022; Huggett, 2020; Torres-Loredo et al., 2022). Algorithmic personalization contributes to the decline of critical thinking by restricting exposure to differing viewpoints. Moreover, the dominance of commercial technology platforms in managing publications and scientific metrics may influence research agendas and compromise academic independence (Annuš, 2024; Samsonovich, 2020; Tariq et al., 2021). The growing use of artificial intelligence in research also raises concerns about the reproduction of existing biases embedded in data (Gagliardi et al., 2023; Jiménez Rios et al., 2023).

In addition to these threats, several structural limitations affect the development of scientific knowledge in the digital era. Digital inequality across regions and institutions constrains participation in the global scientific community (Asyibli et al., 2025; Hasibuan et al., 2024; Kalyani, 2024). The authority of scientific expertise is increasingly challenged by alternative sources of knowledge that do not necessarily adhere to rigorous scientific methodologies. Furthermore, ethical issues in big data research such as privacy, informed consent, and algorithmic accountability have become more complex and require serious attention.

Although numerous studies have examined digitalization in relation to scientific knowledge, most have focused on technical and practical aspects. Comprehensive analyses that integrate both structural limitations and epistemological threats within the Indonesian context remain limited, particularly for the recent period of 2020–2025. Therefore, this study seeks to address this gap by employing a systematic literature review to provide a deeper understanding of

these dynamics. In line with this analytical framework, this study is formulated into the following research questions:

- RQ 1. What are the main structural limitations affecting the development of scientific knowledge in the digital era?
- RQ 2. What epistemological and social threats emerge from digital transformation in the context of scientific knowledge?
- RQ 3. What are the implications of these limitations and threats for the sustainability and integrity of scientific knowledge?

METHODS

This study employs a systematic literature review (SLR) with a critical approach to examine the structural limitations and epistemological threats to scientific knowledge in the digital era. The review focuses on scholarly works published between 2020 and 2025, ensuring the relevance of the analysis to recent developments (Calderón & Ruiz, 2015; Eltoukhi et al., 2025; Whittemore & Knafl, 2005; Wilson & Liu, 2010; Wu & Shen, 2016).

The primary data sources consist of peer-reviewed journal articles indexed in national databases (minimum SINTA 3 to SINTA 1), research reports published by recognized institutions such as national research agencies and government bodies, and multidisciplinary academic journals published in Indonesia. These sources were selected to capture both empirical findings and policy-oriented perspectives related to digital transformation in scientific practices (Assemblali & Sabar, 2022; Engkizar et al., 2023; Engkizar et al., 2025; Topping et al., 2022; Winnaandhini & Santosa, 2025).

The literature search was conducted using a set of predefined keywords, including “digital scientific knowledge Indonesia,” “science misinformation,” “digital critical thinking,” “academic platform hegemony,” and “AI ethics in research.” The selection process involved screening titles, abstracts, and full texts based on their relevance to the research objectives, particularly their discussion of structural constraints and epistemological challenges in the digital context (Kassymova et al., 2025; Saiddaeni & Firmansyah, 2023; Topping et al., 2022; van Laar et al., 2017).

Data analysis was carried out using a combination of content analysis and critical discourse analysis (CDA). Content analysis was applied to systematically categorize recurring themes, patterns, and key issues identified in the literature (Bartlett & Vavrus, 2016; Dalglish et al., 2021). Meanwhile, critical discourse analysis was used to examine underlying power relations, ideological influences, and dominant narratives shaping the discourse of scientific knowledge in the digital era (Baroud et al., 2025; Rahman et al., 2025).

To ensure the validity and reliability of the findings, this study employed data triangulation and theoretical triangulation. Data triangulation was conducted by comparing multiple types of sources, including academic articles and institutional reports, while theoretical triangulation involved interpreting the findings through different theoretical perspectives to confirm or challenge emerging patterns (Ashour, 2018; Lemon & Hayes, 2020; Thompson, 2023). This approach strengthens the analytical rigor and enhances the credibility of the study.

RESULT AND DISCUSSION

The systematic analysis of 15 selected studies reveals that the development of scientific knowledge in the digital era is shaped by a complex interaction between structural limitations and emerging epistemological threats. These findings indicate that digital transformation does not merely enhance knowledge production but also introduces new vulnerabilities that affect the integrity and authority of science (Amalia et al., 2025; Hosseini et al., 2022; Roberts, 2023).

In terms of structural limitations, the findings highlight the persistence of academic digital inequality (digital divide), particularly between well-established universities and institutions in less developed regions. Access to international journals and high-performance computational tools remains uneven and is often dependent on costly institutional subscriptions (Djenontin & Meadow, 2018; Izahari, 2022; Roberts, 2023). This condition limits the participation of scholars in global scientific discourse and reinforces existing disparities in knowledge production. In addition, a crisis of scientific authority has emerged, marked by the proliferation of pseudo-scientific content on digital platforms. Information such as unverified alternative medicine or climate conspiracy theories is often presented in persuasive formats, blurring the boundary between opinion and evidence-based knowledge (Belle & Zhao, 2023; Gupta & Gupta, 2023). Furthermore, ethical dilemmas in big data research have become increasingly prominent. Many studies utilizing social media data tend to overlook issues of privacy, informed consent, and data accountability, largely due to the absence of clear regulatory frameworks.

Alongside these limitations, several significant threats to scientific knowledge are identified. One of the most dominant is the widespread dissemination of misinformation and disinformation, particularly during major events such as the COVID-19 pandemic and the 2024 election (Pebrianto & Mulyono, 2024; Wirawan et al., 2021). Scientific terminology is frequently misused to legitimize misleading claims, which in turn erodes public trust in authoritative science. Another critical issue is the decline of critical thinking, even among academics. The findings suggest that early-career researchers increasingly rely on easily accessible sources, such as popular academic blogs or non-peer-reviewed preprints, rather than rigorously validated primary literature. This tendency is reinforced by algorithm-driven recommendation systems that prioritize convenience over quality (Bourblanc, 2019; Roberts, 2023).

Moreover, the dominance of digital platforms and metrics has contributed to what is often referred to as the “*metric tide*”, where quantitative indicators such as citation counts and H-index become the primary benchmarks of academic success (Chin Roemer & Borhardt, 1976; Hassan & Duarte, 2024; Voukkali et al., 2023). This phenomenon risks marginalizing the social relevance and intellectual depth of research. In addition, the growing use of artificial intelligence tools in research processes including data analysis, literature review, and manuscript writing raises concerns about embedded bias and the phenomenon of algorithmic hallucination, which may lead to misleading or inaccurate conclusions if not critically evaluated (Engkizar et al., 2025; Santos et al., 2023).

These findings suggest that digitalization has driven a shift in the epistemology of scientific knowledge toward a more fluid, fragmented, and contested form. The relationship between digital technology and epistemological change is inherently dialectical (Azer & Oran, 2023; Kesuma et al., 2025; Suhendi, 2024). On the one hand, digital platforms democratize access to knowledge; on the

other hand, the commercial and algorithmic logic underlying these technologies may constrain intellectual autonomy and weaken critical scientific reasoning.

When viewed in relation to existing theories, these findings support the argument regarding the scientization of politics and the politicization of science, as discussed by (Bourblanc, 2019). In the Indonesian context, this is reflected in the politicization of scientific issues such as climate change and vaccination. While global studies often emphasize misinformation as a primary threat, this study, in line with previous research, shows that the impact is exacerbated by relatively low levels of digital literacy and a weak culture of respecting scientific authority (Head et al., 2018; Ng, 2012).

The implications of these findings are significant across multiple domains. In the field of education, there is a pressing need to reform curricula by integrating critical digital literacy, including the ability to evaluate digital sources, understand algorithmic systems, and develop informed scepticism (Abu et al., 2022; Anggraeni et al., 2023; Kuputri, 2020; Soraya et al., 2023). In the research sector, institutions and policymakers should prioritize the development of national open science infrastructures, such as independent repositories and open-access journals, to reduce dependence on commercial platforms and enhance equitable access (Kassymova, et al., 2025). At the societal level, sustained science and digital literacy campaigns are essential, involving scientists as active communicators in digital spaces to reclaim the authority of scientific discourse.

CONCLUSION

This study concludes that the digital era presents a paradox for the development of scientific knowledge in Indonesia. While digitalization expands access and accelerates knowledge production, it also introduces structural limitations and reinforces threats to the integrity, authority, and social function of science. The main challenge lies not in the technology itself, but in the lack of systemic readiness in education, regulation, and research infrastructure to critically manage its impact.

The findings highlight that digital inequality, the erosion of scientific authority, ethical issues in big data research, and the spread of misinformation are interconnected challenges that reshape the epistemological landscape of science. Without proper intervention, these dynamics risk weakening critical thinking and undermining public trust in science.

To address these issues, this study recommends strengthening ethical regulations for digital research, integrating critical digital literacy into education systems, developing national open science infrastructure, and promoting collaborative science communication to counter misinformation. These efforts are essential to ensure that digital transformation supports, rather than undermines, the sustainability and advancement of scientific knowledge.

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Author contribution

Nurul Fathinah F Hamid: Writing-Preparation of original manuscript,

Visualization, **Mustamin Giling:** Conceptualization, Methodology, Data accuracy and analysis, **Masita L Hi. Muhammad:** Investigation, Improve Content, Improve Language.

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