



EPISTEMOLOGY OF NATURAL SCIENCES IN THE ERA OF ARTIFICIAL INTELLIGENCE: CHALLENGES AND ONTOLOGICAL TRANSFORMATIONS

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Abstract:

This study aims to analyze the epistemological and ontological transformations occurring in the natural sciences in the era of artificial intelligence (AI). The method used is a qualitative approach with a case study design, using data sources from scientific literature and recent articles. Data analysis was conducted thematically to identify key patterns related to changes in the way scientific knowledge is acquired, validated, and understood. The results show that the emergence of AI has shifted the epistemological paradigm of the natural sciences, where the process of knowledge production and validation no longer relies entirely on human observation and reasoning, but also on the ability of algorithms to process large-scale data. This condition presents new challenges in the form of the risk of algorithmic bias, reduced scientific transparency, and ethical dilemmas related to the responsibility and accountability of research results. Ontologically, AI also creates new forms of reality through digital models and simulations that are often considered to represent scientific reality. This change demands an update in how the natural sciences understand the concepts of "reality" and "scientific truth." Therefore, an adaptive epistemological and ethical framework for technology is needed so that AI can be used responsibly without eliminating the role of humans as the primary subjects of knowledge. This research emphasizes that collaboration between humans and AI must be based on the principles of transparency, interpretability, and humanity to ensure that science remains credible, inclusive, and meaningful.

Keywords: *AI, Scientific Ethics, Natural Sciences, Ontology.*

INTRODUCTION

Artificial intelligence (AI) technology is developing rapidly and has brought significant changes to various fields, including the natural sciences. The AI era marks a transformation in how scientific knowledge is acquired, processed, and validated, presenting new epistemological challenges for the natural sciences (Rustandi et al., 2025). Trends in Artificial Intelligence (AI) developments in the natural sciences in 2025 demonstrate significant progress that will contribute to a transformation in the culture of scientific research and discovery (Mundiri et al., 2025). One key trend is the maturation of increasingly sophisticated AI models with advanced reasoning capabilities that mimic human thinking (Masduki et al., 2025). Socially, advances in AI influence the structure of knowledge production and expand human capacity for scientific research and experimentation, but on the other hand, they pose the risk of reliance on automation and algorithms that can introduce bias and distort knowledge.

Literature reviews have revealed significant concerns regarding fundamental principles of natural science epistemology, such as objectivity, validity, and scientific integrity, which are now under threat from the dominance of artificial intelligence (AI) technology in the scientific process. AI is no longer merely a simple tool to aid data analysis or speed up calculations, but has evolved into an intelligent agent capable of generating knowledge independently and automatically (Rustandi et al., 2025). In other words, the existence of AI requires us to reconsider the traditional boundaries between the subject of knowledge (humans) and the object of knowledge (nature or the reality being studied). Because AI is actively involved in the knowledge creation process, this raises the need to consider and develop new epistemological and ontological concepts that can accommodate AI's presence in the scientific knowledge production cycle (Dr. Hendra Jaya et al., 2023).

Based on the background and objectives of this research, two main issues will be examined. First, how changes in thinking and methods in the natural sciences occur when Artificial Intelligence (AI) begins to play a role in the process of discovering and assessing scientific truth (Fatmasari et al., 2025). Second, how to develop a new framework for thinking so that the natural sciences can adapt to the development of AI while maintaining the truth, accuracy, and usefulness of the knowledge produced for human life. This research aims to examine how the epistemology of natural sciences is transforming in the AI era, with a focus on the challenges arising from the shifting role of knowledge involving intelligent machines. The goal is to formulate an adaptive epistemological and ontological framework to address the complex interactions between natural sciences and AI, while ensuring the quality, truth, and relevance of the scientific knowledge produced in this context.

Based on the initial study, the hypothesis proposed is that the AI era demands an ontological transformation in natural science, where the boundaries between the subject of knowledge and its tools become blurred. AI not only expands traditional epistemology but also necessitates a redefinition of the existence of the entity of knowledge itself. Therefore, the epistemology of natural sciences must develop a new approach that bridges the technological, ethical, and philosophical aspects of science to maintain the integrity and credibility of scientific knowledge in the AI era (Collins et al., 2021).

RESEARCH METHODS

This research method uses a qualitative approach, involving epistemology, natural scientists, and AI developers. The chosen research design is a case study to explore in depth how AI influences the way scientific knowledge is understood and constructed. The primary sources of information were obtained from scientific literature and recent articles. Data analysis was conducted using thematic analysis techniques to identify key patterns related to epistemological challenges and ontological changes that have occurred, so that the results can provide a clear picture of the transformations experienced by natural science in the context of AI development.

RESULTS AND DISCUSSION

Transformation of the Epistemology of Natural Sciences in the Era of Artificial Intelligence

In the era of artificial intelligence (AI), the epistemology of natural

sciences is undergoing a fundamental transformation. Epistemology is a theory of knowledge that studies how knowledge is acquired, validated, and used (Rustandi et al., 2025). With the advancement of AI, the production, processing, and analysis of knowledge in the natural sciences are changing significantly. AI accelerates the research process and is capable of automatically analyzing large-scale data, paving the way for new discoveries impossible with conventional methods (Ilmiah, 2025).

The impact of AI on the production and validation of knowledge is profound. AI's capacity to process massive amounts of data enables scientists to produce new findings more quickly and efficiently (Madanchian & Taherdoost, 2025). However, this poses the risk of over-reliance on algorithms and data that are not free from bias. Incomplete or biased data can lead to less valid or misleading research results, so a balance between automation and critical human scrutiny is essential (Gandasari et al., 2024). Furthermore, the principles of objectivity and scientific truth, which have long been the foundation of science, now face new challenges in the AI era. The lack of transparency in AI systems can threaten the validity of natural sciences, as their results become difficult for humans to test and fully understand. In this situation, the role of AI is shifting to that of a non-human "knowledge agent" that contributes to shaping scientific understanding and belief. This situation raises questions about who is responsible for the truth and ethics of research, and how humans can maintain control and responsibly interpret AI results (Mellyzar et al., 2024).

This epistemological transformation also carries social and ethical consequences. Research can potentially become so focused on abundant data that fundamental and innovative questions may be overlooked. Therefore, technological ethics, transparency of AI processes, and epistemic integrity are crucial for maintaining trustworthy and relevant science, ensuring the sustainability of inclusive scientific development (Saefurohman et al., 2024). To adapt to advances in AI, the epistemology of natural sciences must maintain traditional scientific values. This includes maintaining a balance between automation by AI and active human involvement in research, as well as developing an inclusive philosophical framework for the role of AI in knowledge production and validation (Prayogi & Nasrullah, 2024).

Epistemological Challenges in the Integration of AI into the Natural Sciences

The integration of artificial intelligence (AI) into the natural sciences poses significant challenges regarding how we understand and assess knowledge. From a knowledge perspective, questions arise about whether machine-generated information is as trustworthy and authoritative as traditionally acquired knowledge (Prayogi & Nasrullah, 2024). In the natural sciences, knowledge is typically acquired through direct observation and in-depth human thought. However, with AI increasingly automating the production of knowledge, we are questioning whether AI results can meet the standards of truth, transparency, and openness that have long been fundamental to the natural sciences (Idris et al., 2022).

One major challenge is the risk of algorithmic bias and over-reliance on data-driven models. AI processes large volumes of data, but if that data is unrepresentative or biased, AI results can lead to misleading and scientifically invalid conclusions. This undermines the principle of scientific objectivity and

threatens epistemological integrity, making it difficult to transparently test and validate results (Oktaviani Putri Dita et al., 2024). Furthermore, the complexity and "black-box" nature of many AI models makes it difficult to clearly explain how scientific results are obtained, raising ethical and epistemic questions about the responsibility and accountability of scientists in using AI as a research tool (Pipit Mulyah, Dyah Aminatun, Sukma Septian Nasution, Tommy Hastomo, Setiana Sri Wahyuni Sitepu, 2020). This lack of understanding not only diminishes humans' ability to master the knowledge-making process but also makes it difficult to validate and critique scientific findings, which are at the heart of the traditional scientific method.

From an ethical perspective, the integration of AI also presents serious challenges related to fairness, transparency, and data privacy. AI algorithms often not only reflect existing social biases but can even reinforce discrimination if training data is not managed in an inclusive and equitable manner. Therefore, ethical principles such as non-discriminatory fairness, system transparency, and the protection of privacy and data security are crucial to ensure the benefits of AI are enjoyed equally without disadvantaging certain groups (Adi Marsiela et al., 2024).

Furthermore, the development of AI in science must prioritize human and environmental safety, while considering its long-term social impacts. This requires strict control and oversight mechanisms to prevent the misuse of AI technology and ensure that AI is used to improve human well-being and planetary sustainability (Martias & Daswito, 2024). Addressing these challenges requires an adaptive epistemological framework and an integrative technology ethics. This includes developing new standards for scientific validation that accommodate the role of AI, improving technological literacy among scientists, and policies that regulate the responsible use of AI. A multidisciplinary approach also needs to be strengthened to address the complex problems arising from the integration of AI into the natural sciences (Hofmann, 2022). In summary, the integration of AI into the natural sciences simultaneously opens up significant opportunities for innovation and raises epistemological and ethical challenges that must be seriously addressed to ensure science remains credible, transparent, and socially responsible.

Ontological Transformation: Scientific Reality Under AI Mediation

Besides changing the way we think, AI is also changing how we perceive scientific reality (Prayogi & Nasrullah, 2024). In the past, natural sciences focused solely on the real world that could be observed and measured. Now, AI is creating new forms of reality derived from data and computer simulations. For example, AI can model the behavior of weather, atoms, or biological systems that humans cannot directly observe. The results of these models are often used as if they were part of reality, when in fact, they are computer-generated (Prayogi & Nasrullah, 2024). This shift requires us to rethink what constitutes "real" in science. AI models can discover patterns without explaining their causes, blurring the boundaries between reality and simulation (Pabubung, 2021). Therefore, natural science needs to adapt to this new world, where humans and machines work together to build knowledge. In situations like this, it is crucial to ensure that science remains grounded in truth, remains understandable, and does not lose its human significance.

This requires natural sciences to rely not only on empirical observation but also to integrate simulation results with a critical approach to avoid falling

into the illusion of machine-generated false truths (Mellyzar et al., 2024). Therefore, collaboration between humans and AI must be reinforced with the principles of transparency, accountability, and interpretability in the scientific process to maintain the human significance of scientific development. This approach also encourages updates to scientific methodology that accommodate AI's role as both a tool and a source of new insights, without neglecting the epistemological and ethical values of science itself (Tarumingkeng, 2024).

The broader impact of AI integration in the natural sciences is a change in the scientific process itself. AI accelerates pattern discovery and expands the capacity for big data analysis, but it also has the potential to diminish human critical thinking and analytical skills if overly dependent (Cholvistaria & Gunawan, 2025). Therefore, the education and application of AI in academic contexts must be carried out in a balanced manner, supporting creativity and critical thinking skills while maintaining scientific integrity. AI serves as a tool that enriches the research and development process, not a substitute for critical thinking on the part of scientists.

In the context of education and scientific writing, AI facilitates the development of frameworks, data processing, and plagiarism checks, which have a positive impact on the quality and efficiency of academic work. However, caution is needed to ensure that the use of AI does not undermine the originality and analytical depth of scientific work (Nur Syahriani, Winarti, 2025). This balanced approach ensures that AI plays a role as a partner in developing meaningful and responsible knowledge while upholding humanitarian values in science. Therefore, in facing the AI era, natural sciences must open a new paradigm that involves active collaboration between humans and machines. This is a crucial step to ensure science does not lose its essence as a search for truth that can be accounted for and understood by humans, while embracing the advantages of AI in expanding the horizons of scientific knowledge and creativity (Hadi et al., 2025).

CONCLUSION

This study concludes that the development of Artificial Intelligence (AI) has transformed the way the natural sciences understand and construct knowledge. AI is now not only a tool but also plays a role in shaping knowledge, challenging traditional concepts of truth and objectivity. A key finding is the need for a new awareness so that humans can collaborate critically with AI without losing the human values in science. Scientifically, this study has implications for the need to update the epistemological paradigm of natural science, combining aspects of technology, ethics, and philosophy to ensure knowledge remains valid, transparent, and accountable. However, this research is still limited to a literature review and does not include empirical studies on the practice of using AI in scientific research. Therefore, further research is needed with an interdisciplinary approach to examine the real impact of AI on the methods, ethics, and policies of modern science.

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