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Philosophy of science and truth: epistemological foundations of scientific knowledge

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ABSTRACT

Purpose: to analyze the relationship between philosophy of science, epistemology, theories of truth, and major philosophical traditions in shaping the foundations and development of scientific knowledge.
Method: this study employed a qualitative library research approach. Data were collected from primary and secondary literature on philosophy of science, epistemology, theories of truth, and major philosophical traditions, and analyzed using content analysis and descriptive-critical analysis.
Findings: scientific knowledge is fundamentally shaped by philosophical assumptions underlying ontology, epistemology, and axiology. Epistemology plays a central role in knowledge construction and justification, while theories of truth, correspondence, coherence, and pragmatism provide complementary perspectives in defining scientific validity. Furthermore, rationalism, empiricism, positivism, post-positivism, and constructivism collectively influence the development of modern scientific paradigms, indicating that scientific knowledge is dynamic, interpretative, and paradigm-dependent.
Implications: a stronger understanding of philosophical foundations is essential for developing more critical, reflective, and ethically responsible scientific research practices.
Originality: this study offers an integrative framework that connects philosophy of science, epistemology, theories of truth, and major philosophical traditions to explain the construction and validation of scientific knowledge.

Introduction

Science is one of the primary instruments humans use to understand reality, solve various life problems, and produce innovations that drive the advancement of civilization (Huxley, 2022). However, scientific knowledge is not born neutrally and independently of the philosophical framework that underlies it (Anjum & Rocca, 2024). Every claim to scientific truth is built on certain assumptions about the nature of reality,

the sources of knowledge, the methods of acquiring knowledge, and the criteria for assessing whether knowledge is true (Grant & Grant, 2023). Therefore, the development of science is inherently linked to philosophical reflection, which shapes the direction, goals, and legitimacy of scientific knowledge (Duarte et al., 2022). In this context, the philosophy of science plays a fundamental role as a reflective foundation for understanding the nature of science, the sources of knowledge, the scientific method, and the limits of scientific truth (Silva, 2022).

In an era of increasingly rapid scientific development, the use of science across various fields of life often emphasizes technical and methodological aspects over understanding the underlying epistemological foundations (Muharleni et al., 2025). Modern research practices tend to focus on data collection and analysis procedures, while reflection on how knowledge is constructed, validated, and recognized as scientific truth remains relatively under-researched. Consequently, many studies are methodologically successful but fail to consider the philosophical assumptions that influence how researchers understand reality, select methods, and interpret research findings. This situation has the potential to lead to a reductionist approach and to limit the depth of analysis of the phenomena being studied.

This issue is increasingly relevant in the context of contemporary scientific developments, marked by increasing integration between disciplines and the emergence of various interacting scientific paradigms. The development of digital technology, artificial intelligence, big data, and an information-based society presents new challenges in determining the validity of knowledge and the criteria for scientific truth (Rascão, 2024). In such a situation, fundamental questions about what truth is, how it can be obtained, and the extent to which knowledge can be considered valid become increasingly important for philosophical study. Therefore, the philosophy of science serves not only as a theoretical study but also as a critical instrument for evaluating the foundations of knowledge that underpin the development of modern science.

Theoretically, the study of the philosophy of science and epistemology has evolved through various perspectives. Epistemology examines the sources, structure, validity, and justification of knowledge, which form the basis for determining scientific truth (Rohmah et al., 2024). Over time, various theories of truth have emerged, offering differing explanations of the criteria for determining whether a statement is true. Correspondence theory holds that correspondence between statements and empirical facts is the measure of truth; coherence theory emphasizes logical consistency within a system of knowledge; while pragmatic theory views truth as based on the practical usefulness and effectiveness of an idea in human life (Chen, 2023; Rubin, 2022; Schmidt & Schmidt, 2026).

These differences in theories of truth are inseparable from the influence of various philosophical schools of thought that have developed throughout the history of human thought. Rationalism holds that reason is the primary source of knowledge, while empiricism asserts that sensory experience is the primary basis for valid knowledge (Alamuti, 2023). The debate between these two schools of thought subsequently gave rise to various epistemological approaches that have become the foundation for the development of modern science (Matthews, 2024). Furthermore, positivism reinforced the dominance of empirical approaches by emphasizing scientific observation and verification (Contini, 2024). However, this approach later drew criticism from post-positivism and constructivism, which assert that knowledge is also influenced by social, cultural, and historical contexts, as well as the paradigms employed by the scientific community. This criticism gained increasing attention following the emergence of

Kuhn's (1970) idea of paradigm shift as the primary mechanism of scientific development (Krauss, 2024).

Although various studies have discussed the philosophy of science, epistemology, theories of truth, and philosophical schools separately, most still focus on conceptual explanations of each and have not integrated the relationships among philosophy of science, theories of truth, and the development of epistemological paradigms within a comprehensive analytical framework. Furthermore, existing studies generally emphasize historical and theoretical aspects without adequately linking them to the multidisciplinary, dynamic challenges of contemporary scientific development. This condition indicates a research gap, with limited studies that systematically analyze the relationships among epistemological foundations, theories of truth, and the influence of various philosophical schools on the construction of scientific knowledge in the context of modern scientific development.

This study offers a novel analytical framework that integrates philosophy of science, epistemology, theories of truth, and various philosophical schools to explain how scientific truth is constructed, validated, and developed. This research not only describes the historical development of philosophical thought in science but also examines its relevance to responding to the challenges of contemporary science, which is increasingly complex and multidimensional. The purpose of this study is to analyze in depth the relationship between philosophy of science, epistemology, theories of truth, and various philosophical schools that influence the development of scientific knowledge. Specifically, this study aims to identify the main concepts in the philosophy of science, explain various theories of truth that have developed in epistemology, and examine the contributions of rationalism, empiricism, positivism, post-positivism, and constructivism in shaping the paradigm of modern science.

This study is important because a comprehensive understanding of the epistemological foundations of science can strengthen the critical awareness of academics, researchers, and practitioners in understanding the process of scientific knowledge formation. Furthermore, this study is expected to encourage the use of research approaches that are not only methodologically sound but also have a clear philosophical foundation, thereby producing knowledge that is more reflective, critical, and scientifically responsible. The expected contribution of this research is to strengthen the conceptual foundations of the study of philosophy of science and epistemology, enrich the discourse on the theory of truth in science, and provide a more integrative framework for understanding the relationship between philosophical paradigms and scientific practice. The findings of this study are also expected to serve as an academic reference for the development of multidisciplinary research and as a reflective foundation for addressing the dynamics of scientific development in the digital era and information-based society.

Method

This study uses a qualitative approach with library research. This approach was chosen because the study focuses on the conceptual analysis of the philosophy of science, the concept of truth, and various philosophical schools that influence the development of science. Library research is a research method that treats literature, scientific documents, and other written sources as the primary objects of analysis to gain a deep understanding of a scientific concept or idea (Saharan et al., 2024). Epistemologically, this study departs from an interpretative paradigm that positions knowledge as a product of human thought construction and requires in-depth

interpretation of the texts, ideas, and contexts of prominent philosophers of science. The interpretive paradigm is used because the study of philosophy aims not only to explain empirical facts but also to understand the meaning, assumptions, and foundations of thinking that underpin a scientific concept (Gannon et al., 2022). In this context, the philosophy of science is understood as a critical reflection on the nature of science, the source of truth, and the validity of scientific knowledge.

The data sources in this study consist of primary and secondary data. Primary data were obtained from the works of prominent figures in the philosophy of science and epistemology, such as Karl Popper, Thomas S. Kuhn, René Descartes, John Locke, and Francis Bacon, as well as from literature on theories of truth and schools of philosophy of science. Secondary data were obtained from scientific journal articles, reference books, proceedings, and previous research relevant to the themes of philosophy of science, epistemology, and the concept of scientific truth. The use of these sources aims to deepen the analysis while building a more comprehensive synthesis. Data collection techniques were carried out through documentation studies, including identifying, reading, classifying, and reviewing relevant literature. The literature selected was chosen for its relevance to the theme, credibility of the sources, and contribution to the development of the study of philosophy of science and epistemology. In library research, data validity depends heavily on the researcher's ability to select authoritative scientific sources directly related to the object of study (Willig, 2008).

The data analysis techniques used were content analysis and descriptive-critical analysis. Content analysis was used to identify the main ideas, concepts, and thought patterns related to the philosophy of science and the theory of truth in the various literatures reviewed. Meanwhile, a descriptive-critical analysis was used to explain and critique the relationship between the concept of truth and philosophical schools of thought, such as rationalism, empiricism, positivism, and constructivism, in the development of modern science. This critical approach is important because the study of the philosophy of science is not only descriptive, but also reflective and evaluative of the scientific paradigms that develop in the scientific community. To maintain data validity, this study used source triangulation by comparing various literature, expert opinions, and relevant prior research. Triangulation was carried out to ensure conceptual consistency and avoid interpretation bias in understanding philosophical thought and the theory of truth. Thus, the results of this study are expected to provide a more systematic, in-depth, and objective understanding of the relationships among the philosophy of science, the concept of truth, and how philosophical schools shape contemporary scientific paradigms.

Results and discussion

The research findings show that the philosophy of science provides a conceptual foundation for understanding the nature of science, the sources and methods of acquiring knowledge, and the criteria for determining scientific truth. Based on an analysis of various literature, the philosophy of science functions not only as a reflection on scientific findings but also as a critical framework for understanding how knowledge is constructed, validated, and developed within the scientific community (Bakhtiar, 2017; Muharleni et al., 2025; Suriasumantri, 2009). These findings demonstrate that the philosophy of science plays a fundamental role in the formation and development of modern science. The research also found that epistemology is a key dimension of the philosophy of science, directly related to the process of scientific knowledge formation. The literature review shows that epistemology discusses the sources of knowledge,

mechanisms of justification, and the standards of validity used to assess knowledge as true (Moser et al., 1997; Rohmah et al., 2024; Whitesmith, 2022). In this context, scientific knowledge is not understood as a collection of accepted facts, but rather as the result of a rational and systematic process that can be tested and critically evaluated.

The results of the literature synthesis indicate that the concept of truth in science develops through several main perspectives. Correspondence theory views truth as the correspondence between statements and empirical facts, coherence theory emphasizes the logical consistency between propositions in a knowledge system, while pragmatic theory assesses truth based on the practical benefits and success of an idea in solving life's problems (Chen, 2023; Haig, 2025; Schmidt & Schmidt, 2026). These findings indicate that scientific truth is not understood in a single way, but rather through various complementary approaches to explaining the validity of knowledge. This study also found that the development of the concept of scientific truth was influenced by various philosophical schools of thought throughout the history of human thought. Rationalism holds that reason is the primary source of knowledge, while empiricism emphasizes experience and observation as the basis for valid knowledge (Matthews, 2024; Rahman & Abidin, 2023) Furthermore, positivism reinforces the importance of empirical verification in science. At the same time, post-positivism and constructivism broaden the understanding that knowledge is also influenced by social and cultural contexts and the paradigms used to understand reality (Kouam, 2025; Krauss, 2024).

The research findings indicate that the relationship between philosophy of science, epistemology, theories of truth, and philosophical schools forms the primary foundation for the development of modern science. The analyzed literature demonstrates that each scientific paradigm has philosophical assumptions that influence how reality is understood, how research methods are selected, and how scientific truth is determined. Thus, the development of science is determined not only by advances in scientific methodology but also by changes in the underlying philosophical paradigms (Kuhn, 1970). Furthermore, the research findings demonstrate that the philosophy of science is highly relevant to contemporary scientific developments. The increasing integration between disciplines, the development of digital technology, and the complexity of global issues demand a deeper understanding of the epistemological foundations of science. In this context, philosophy of science serves as a reflective framework that allows for critical evaluation of the process of knowledge production and the use of science in human life (Bertens, 2013; Muharleni et al., 2025; Silva, 2022). Overall, the research findings reveal that philosophy of science, epistemology, theories of truth, and various philosophical schools are interrelated elements in shaping the construction of scientific knowledge. This relationship shows that scientific truth is not determined solely by methodological procedures but also by the philosophical foundations that underpin understanding reality, acquiring knowledge, and validating scientific findings.

Discussion

The research findings indicate that the philosophy of science plays a fundamental role in shaping the foundations of scientific knowledge. This finding confirms that science does not develop neutrally, but is always influenced by philosophical assumptions about the nature of reality, the sources and methods of acquiring knowledge, and the criteria of truth used. Thus, the development of science is determined not only by advances in research methodology but also by the underlying philosophical paradigm. This finding aligns with Boon et al. (2022); Verawati & Sarjan

(2023), who asserted that the philosophy of science serves as a critical reflection on the process of knowledge formation and a means of evaluating the validity and limits of scientific knowledge. In this context, the philosophy of science serves as a conceptual framework that ensures that the development of science remains within the corridors of rationality, objectivity, and scientific responsibility.

One of the main findings of this study is the importance of epistemology as a foundation for the formation of scientific knowledge. The results of the study indicate that epistemology not only discusses the sources of knowledge but also explains how knowledge can be justified and accepted as scientific truth. This finding reinforces the views of Moser et al. (1997); Rohmah et al. (2024), who place epistemology at the core of the knowledge validation process. In research practice, epistemological aspects significantly influence the choice of methods and data collection techniques, as well as how researchers interpret research results. Therefore, each research approach actually contains certain epistemological assumptions. Quantitative research, for example, is heavily influenced by positivist views that emphasize objectivity and empirical measurement, while qualitative research is more closely aligned with interpretive and constructivist paradigms that place subjective meaning at the heart of understanding reality. These findings demonstrate that epistemological understanding has direct implications for the quality and direction of scientific development.

The development of the philosophy of science also demonstrates that science is fundamentally never value-free. Every scientific development is always influenced by the paradigm of thought that develops during a particular period. In the history of epistemology, rationalism and empiricism are two major schools of thought that have significantly influenced the development of modern scientific methodology. Rationalism holds that reason is the primary source of knowledge and that truth can be achieved through systematic, logical reasoning. Conversely, empiricism asserts that experience and observation are the primary foundations for forming valid knowledge (Silva, 2022). The findings of this study indicate that these two schools of thought are inseparable from the development of modern science, as they make complementary contributions. Rationalism provides a logical framework for constructing theories, while empiricism provides a mechanism for testing them through observation and empirical experience. This finding aligns with Mustafo (2024); Aguilar (2026), who explain that the development of modern scientific methodology is the result of a synthesis between human rational capacity and empirical experience.

The research findings also reveal that the concept of truth in the philosophy of science is not a single concept. The literature review shows that correspondence theory, coherence theory, and pragmatism offer distinct perspectives on the nature of scientific truth. Correspondence theory assesses truth based on the correspondence between statements and empirical facts. Coherence theory places logical consistency within a knowledge system as a measure of truth, while pragmatist theory assesses truth based on the practical efficacy of an idea in solving life's problems (Etuk, 2022; Haig, 2025; Schmidt & Schmidt, 2026). These findings demonstrate that no single theory of truth can fully account for all dimensions of scientific knowledge. In modern scientific practice, these three theories are often used in a complementary manner. A scientific theory is not only required to be consistent with empirical facts but also to be logically consistent and capable of providing real benefits to human life (Russell & Linsky, 2025). Thus, scientific truth can be understood as a construct that simultaneously involves empirical, rational, and pragmatic dimensions.

The findings of this study also demonstrate that positivism has had a significant influence on the development of modern science, particularly in shaping the quantitative research tradition. Positivism holds that empirical facts are the primary basis of knowledge, making observation, measurement, and verification essential principles of the research process (Ali, 2024). This approach has made a significant contribution to the production of systematic, objective, and testable knowledge. However, the study also shows that the dominance of positivism has drawn criticism for oversimplifying complex social realities. Social phenomena cannot always be reduced to numbers or mechanistic cause-and-effect relationships. Many aspects of human life are related to meaning, experience, values, and interpretations that cannot be fully explained through a positivistic approach (Kaluarachchi, 2025). These findings demonstrate that the development of science requires a more flexible approach to understanding the complexity of reality.

Criticism of positivism subsequently gave rise to various alternative paradigms, particularly post-positivism and constructivism. Research shows that constructivism views knowledge as a human construct formed through social interactions, life experiences, and specific cultural contexts (Zahavi, 2022). This approach provides a broader scope for understanding subjective experiences and social meanings that the positivistic paradigm cannot adequately explain. This finding aligns with the development of qualitative research, which is increasingly used to understand social phenomena deeply. However, this research also found that constructivism faces challenges related to the relativism of knowledge, as the boundaries between fact and interpretation become more complex. Therefore, a balance between scientific objectivity and contextual understanding is necessary to ensure that the resulting knowledge maintains strong academic validity.

The findings of this study are further strengthened by Kuhn's (1970) account of scientific paradigms, which explains that scientific development does not occur linearly through the mere accumulation of facts, but rather through scientific revolutions that result in paradigm shifts. The results show that the shift from rationalism to empiricism, from positivism to post-positivism, and the development of constructivism are clear examples of paradigm shifts in the history of science. These findings indicate that scientific truth is dynamic and open to revision when existing paradigms no longer adequately explain phenomena. Thus, scientific development must be understood as a continuous process of dialogue, criticism, and renewal (Hunt et al., 2022; Weigand, 2023).

Another important finding is the persistent tendency of modern research to focus on methodological technicalities rather than underlying philosophical reflection. Many studies emphasize data collection and analysis procedures but pay little attention to the ontological, epistemological, and axiological assumptions that underpin the research. This situation has the potential to cause research to lose conceptual depth and produce only technical findings. This finding supports the research findings of Muharleni et al. (2025); Liu et al. (2025), which showed that understanding the philosophy of science plays a crucial role in improving the quality of researchers' scientific reflection. By understanding the philosophical foundations of a research method, researchers can be more critical in selecting approaches, interpreting data, and constructing stronger scientific arguments.

In addition to the epistemological aspect, this study also shows that the axiological dimension of philosophy of science is becoming increasingly important in addressing contemporary scientific and technological developments. Advances in digital

technology, artificial intelligence, big data, and other technological innovations have significantly improved human life. However, these developments also present various ethical issues such as data privacy, information manipulation, algorithmic bias, and technological misuse (Dhirani et al., 2023; Tsamados et al., 2022). These findings demonstrate that science cannot be separated from moral and social responsibility. Therefore, the philosophy of science plays a strategic role as a space for critical reflection, ensuring that scientific development is not solely oriented towards technical progress but also considers humanitarian values, justice, and social sustainability.

Overall, this study demonstrates that philosophy of science, epistemology, theories of truth, and various philosophical schools are interrelated components in forming the foundation of scientific knowledge. This finding reinforces previous studies that position philosophy of science as a reflective basis for the development of science. However, this study makes a more integrative contribution by systematically linking the concepts of philosophy of science, theories of truth, epistemological paradigms, and the challenges of contemporary science within a single analytical framework. Thus, this study confirms that understanding the philosophical foundations of science is not only important for academic purposes but also a prerequisite for developing science that is critical, reflective, responsible, and relevant to the needs of modern society.

Conclusions

Philosophy of science, epistemology, theories of truth, and various philosophical schools are closely related in forming the foundation of scientific knowledge. The results of this study reveal that scientific truth is not constructed solely through methodological procedures but is also influenced by philosophical assumptions that underlie how humans understand reality, acquire knowledge, and validate scientific findings. Epistemology is found to be a central dimension in explaining the source, validity, and justification of knowledge, while correspondence theory, coherence, and pragmatism provide complementary perspectives on scientific truth. In addition, rationalism, empiricism, positivism, post-positivism, and constructivism have been shown to make important contributions in shaping the paradigm of modern science. These findings emphasize that the development of science results from the interaction between scientific methodology and philosophical paradigms, which continue to evolve through a process of criticism, evaluation, and paradigm shift.

Theoretically, this study contributes to a more integrative framework for understanding the relationship between philosophy of science, epistemology, theories of truth, and philosophical schools of thought in the development of science. This study broadens the discourse on the philosophy of science by discussing not only conceptual and historical aspects but also situating it in the context of contemporary scientific challenges characterized by the development of digital technology, interdisciplinary integration, and the increasing complexity of global issues. Practically, the results of this study can serve as a reflective foundation for academics and researchers to understand the importance of ontological, epistemological, and axiological dimensions in research practice. However, this study has limitations because it uses a library approach that focuses on conceptual analysis and therefore does not include empirical data regarding the implementation of the philosophy of science paradigm in research practice across various disciplines.

Further research is recommended to develop more empirical studies that explore the application of various epistemological paradigms in contemporary research practices across the social sciences, humanities, and science and technology. Future

research can also examine more specifically the relevance of the theory of truth and the philosophy of science in addressing current issues such as artificial intelligence, digital ethics, big data, and the transformation of an information-based society. Furthermore, an interdisciplinary approach that integrates philosophical perspectives, research methodologies, and modern technological developments is needed to produce a more comprehensive understanding of the construction of scientific knowledge in the contemporary era. Thus, the philosophy of science can continue to play a critical and reflective role in guiding the development of science that is not only scientifically valid but also socially and ethically responsible.

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