ALSYS
Jurnal Keislaman dan Ilmu Pendidikan

e-ISSN : 2808-540X
p-ISSN : 2808-7119

Terindeks: Copernicus, Sinta 5, Dimensions, Scilit, Lens, Semantic Scholar, Garuda, Google, Base, etc.

https://doi.org/10.58578/alsys.v6i5.11692

EMPIRICISM AS A BRANCH OF PHILOSOPHY AND ITS INFLUENCE ON THE DEVELOPMENT OF SCIENCE AND TECHNOLOGY IN THE ISLAMIC WORLD

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Article Info:

Submitted:	Revised:	Accepted:	Published:
Jun 21, 2026	Jul 19, 2026	Jul 31, 2026	Aug 5, 2026

Abstract

Empiricism constitutes a major branch of epistemological philosophy that emphasizes observation, experimentation, induction, and verification as foundations of knowledge; however, its relationship with scientific development in the classical Islamic world requires further systematic examination. This study analyzes the principles of empiricism and their contribution to the advancement of science and technology in the classical Islamic intellectual tradition. Employing a qualitative descriptive-analytical library research design, the study examines primary texts by Western empiricist philosophers, Qur'anic and hadith-based epistemological sources, and the works of classical Muslim scholars, supported by relevant secondary literature. The findings indicate that the core principles of empiricism were reflected in the scientific practices of Ibn al-Haytham, Al-Biruni, Jabir ibn Hayyan, Al-Razi, Ibn Sina, and other Muslim scholars. Their contributions to optics, astronomy, chemistry, medicine, and mathematics demonstrate a systematic reliance on observation, experimentation, and empirical verification rather than speculative reasoning alone. The analysis further shows that Islamic epistemology provides a compatible foundation for empirical inquiry by integrating revelation, reason, and sensory experience. This

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synthesis enabled Muslim scholars to develop a distinctive scientific tradition characterized by methodological rigor and spiritual orientation. The study concludes that the historical legacy of Islamic empiricism offers a relevant framework for revitalizing contemporary science and technology in the Muslim world. Its principal contribution lies in demonstrating that the renewed application of observation, experimentation, and critical verification within an Islamic epistemological framework may strengthen scientific development while maintaining ethical and theological coherence.

Keywords: Classical Islamic Science; Empirical Inquiry; Empiricism; Epistemology; Islamic Intellectual Tradition

INTRODUCTION

Philosophy, as the mother of all sciences, has given rise to various branches of thought that have shaped human scientific paradigms throughout the history of civilization. One branch of philosophy that has had a significant influence on the development of science is empiricism. Empiricism is a philosophical school that emphasizes that human knowledge is derived from sensory experience and direct observation of natural phenomena (Ariani & Anwar, 2023). This view differs fundamentally from rationalism, which prioritizes reason as the primary source of knowledge. In the context of the development of science and technology, empiricism provides a strong methodological foundation for the birth of the modern scientific method, which is based on observation, experimentation, and empirical verification. Islamic civilization during its golden age, particularly between the 8th and 13th centuries AD, demonstrated extraordinary achievements in various fields of science and technology. Muslim scientists such as Ibn Sina, Al-Biruni, Ibn al-Haytham, and Al-Khwarizmi not only mastered the scientific heritage of previous civilizations but also developed it through a systematic, observation-based approach. They conducted meticulous experiments, observations, and measurements to understand natural phenomena, reflecting the empirical spirit of the Islamic scientific tradition. Their contributions to mathematics, astronomy, medicine, chemistry, and optics laid the foundation for the later development of modern science (Hidayat & Rijal, 2024).

The relationship between empiricism as a philosophical method and the Islamic scientific tradition is an interesting topic for in-depth study. The Quran itself contains numerous verses that encourage humans to observe the universe, reflect on God's creation,

and use reason and sensory experience as a means of acquiring knowledge. Verses that call on humans to "walk on the earth" and "pay attention" to various natural phenomena demonstrate Islam's appreciation of empirical observation and experience. This created an intellectual climate conducive to the development of empirical approaches within the classical Islamic scientific tradition (Syarip et al., 2026). Muslim philosophers such as Ibn Rushd attempted to reconcile revelation and reason, religion and philosophy, in a non-contradictory manner. In epistemological terms, they recognized the crucial role of sensory experience in gaining knowledge about the physical world, while also acknowledging the limitations of human senses in understanding metaphysical reality. This integrative approach enabled Muslim scientists to develop science based on empirical observation while maintaining their theological framework. This synthesis of the spiritual dimension and empirical methods is a distinctive characteristic of the Islamic scientific tradition, distinguishing it from the development of science in other civilizations (S. M. Ichsan & Taran, 2023).

The advancement of science and technology in the Islamic world during the classical period was inseparable from the application of empirical methods in scientific research. Ibn al-Haytham, for example, is known as the father of modern optics for his systematic approach to conducting experiments to understand the nature of light and vision (Fauzi & Chudzaifah, 2019). He rejected speculative theories unsupported by empirical evidence and developed rigorous experimental methods. Similarly, Al-Biruni made precise measurements to determine the circumference of the Earth, Jabir ibn Hayyan developed experimental methods in chemistry, and Al-Razi conducted systematic clinical trials in medicine. All of these achievements demonstrate the application of empiricist principles to Islamic scientific practice. However, the relationship between Western philosophical empiricism and the Islamic scientific tradition remains a matter of academic debate.

Some scholars argue that empiricism as a systematic philosophical school is more a product of modern European thought pioneered by John Locke, George Berkeley, and David Hume. Meanwhile, others argue that the seeds of empiricism were already present in the Islamic scientific tradition long before its emergence in Europe, and that there was a transmission of knowledge and methods from the Islamic world to Europe through various routes such as Andalusia and Sicily. This debate is important for understanding the genealogy of empirical epistemology and the role of the Islamic world in the development of the modern scientific method (Lesmana et al., 2025).

The relevance of this study is increasingly important in the contemporary context, where the Islamic world faces the challenge of catching up in science and technology. Understanding how empiricism as a philosophical approach contributed to scientific and technological progress during the Islamic Golden Age can provide valuable insights for revitalizing the Islamic scientific tradition in the modern era (Ihsanuddin et al., 2024). In addition, this study can also show that there is no fundamental conflict between Islamic values and empirical methods in the development of science, so that it can encourage a more harmonious integration between religion and science in contemporary Muslim society.

Research on empiricism and its influence on the advancement of science and technology in the Islamic world also has broader philosophical implications. This study can enrich discussions of epistemology by showing how various intellectual traditions have distinct yet complementary approaches to understanding reality. Furthermore, this research can contribute to the dialogue of civilizations by demonstrating that scientific achievements are the result of the accumulation of knowledge across cultures and civilizations, not the monopoly of any one tradition. Thus, this study has not only historical and philosophical value but also practical relevance in the context of the development of science and technology in the contemporary Islamic world (Sari & Sirait, 2021).

Based on the background outlined above, this study formulates several key issues for in-depth examination. First, it seeks to explain the concept of empiricism as a branch of epistemological philosophy and its fundamental principles in understanding the sources of human knowledge. Second, it investigates how these empirical principles were manifested in the classical Islamic intellectual tradition, particularly in the works of leading Muslim scholars during the golden age of Islamic civilization. Third, it examines the extent to which the application of empirical methods contributed to the advancement of science and technology in the classical Islamic world, especially in fields such as mathematics, astronomy, medicine, chemistry, and physics. Fourth, it explores the challenges and opportunities involved in integrating empirical approaches with the framework of Islamic epistemology, as well as the relevance of this understanding for revitalizing the Islamic scholarly tradition in the contemporary era.

This study aims to provide a comprehensive analysis of empiricism as a branch of epistemological philosophy and to clarify its fundamental principles regarding the source and validity of knowledge. It also seeks to identify and analyze how empirical principles were

applied in the classical Islamic scholarly tradition through the works of prominent Muslim?—replace with "scholars" in English—to evaluate the concrete contributions of empirical methods to the progress of science and technology during the Islamic golden age, and to explore the philosophical and practical implications of the relationship between empiricism and Islamic epistemology. Ultimately, this research is expected to offer recommendations on how this historical and philosophical understanding can be utilized to promote the advancement of science and technology in the contemporary Islamic world.

METHODS

This research employs a qualitative method with a descriptive-analytical approach. This type of research is library research, aiming to describe and analyze the concept of empiricism and its influence on the development of science and technology in the Islamic world. Qualitative methods were chosen because this research focuses on an in-depth understanding of philosophical concepts and historical contexts through text and document analysis (Cresswell, 2012; Sugiyono, 2019). The historical-philosophical approach is used to trace the development of empiricist thought and its manifestations in the Islamic scientific tradition. Furthermore, this research employs a comparative approach to compare the principles of empiricism in Western philosophy with Islamic epistemology, thus identifying the relationship and influence between the two traditions.

Primary data sources in this study include the works of empiricist philosophers such as John Locke and David Hume, as well as the works of classical Muslim scholars such as Ibn al-Haytham, Ibn Sina, Al-Biruni, and Al-Razi. Primary data also include the Quran and Hadith as references for Islamic epistemology, as well as the works of Muslim philosophers such as Ibn Rushd and Al-Ghazali, who discuss the theory of knowledge. Secondary data sources consisted of books, scientific journals, and academic articles discussing empiricism, the philosophy of science, and the history of Islamic science. This secondary literature was used to provide context and analysis for the primary sources. Various sources from digital libraries and academic databases were also utilized to complement the research study (Adji, 2024; Yusuf, 2016).

Data collection was conducted through documentation studies by identifying and reviewing relevant documents. Literature searches were conducted using keywords such as empiricism, Islamic epistemology, and classical Islamic science in various academic

databases. The documents found were then selected based on their relevance and credibility to the research topic. Content analysis techniques were used to extract key information from the collected texts. Researchers critically read primary sources to identify key concepts and evidence for the application of empirical methods in the work of Muslim scholars. Important quotations were noted and categorized by theme to facilitate the analysis process.

Data analysis employed qualitative content analysis methods, which involved coding, categorizing, and interpreting textual data. The first stage was data reduction, which involved selecting information relevant to the research problem. The data was then coded based on key concepts and grouped into categories such as principles of empiricism, observational methods, and contributions to specific scientific fields. The next stage was a comparative analysis to compare Western empiricist concepts with Islamic scientific practices. Triangulation was carried out by comparing interpretations from various sources to validate the findings. The results of the analysis were then synthesized and presented in the form of a systematic narrative description to answer the research problem formulation (Safrudin et al., 2023).

Data validity was ensured by using sources with academic credibility. Source triangulation was carried out by comparing information from various references to ensure data consistency. In interpreting classical texts, the researcher referred to the opinions of recognized experts in Islamic philosophy and the history of science. Systematic documentation of the entire research process was carried out to ensure the results could be traced and verified (Rosidah et al., 2023). Each claim or argument presented was accompanied by clear citations and references, allowing readers to verify the accuracy of the interpretations presented in this study.

RESULTS

Basic Concepts of Empiricism as a Branch of Philosophy

Empiricism is a major school of epistemological philosophy that emphasizes that human knowledge originates from sensory experience. This school developed in response to rationalism, which prioritizes reason as the primary source of knowledge. Empiricist philosophers such as John Locke rejected the concept of innate ideas and argued that the human mind was initially a tabula rasa, or blank slate, that was then filled through experience. This experience can be external through the sensation of physical objects, or internal through

reflection on our own mental operations. David Hume developed empiricism in a more radical direction by distinguishing between impressions and ideas. According to Hume, all our knowledge comes from sensory impressions that then form ideas in our minds. He also introduced a critique of the concept of causality, stating that the cause-and-effect relationships we believe are actually just mental habits based on repeated experience, not knowledge that can be rationally proven. Hume's thinking had a major impact on the development of the philosophy of science and the modern scientific method. Francis Bacon, as a pioneer of modern empiricism, developed the method of induction as a systematic way to gain knowledge from specific observations to generalizations. This Baconian method emphasizes the importance of observation, experimentation, and the collection of empirical data as the basis for formulating scientific theories. Bacon also identified various idols or prejudices that hinder humans from obtaining objective knowledge, such as the idol of tribus, the idol of specus, the idol of fori, and the idol of theatri. Bacon's contribution laid the foundation for the scientific method that developed in the modern era and distinguished science from mere philosophical speculation (Pakpahan et al., 2022).

Islamic Epistemology and Sources of Knowledge

Islamic epistemology has a comprehensive view of the sources of human knowledge. The Quran and Hadith, the primary sources of Islamic teachings, contain numerous verses and instructions that encourage humans to use reason, observe the universe, and reflect on God's creation. Verses such as "Say, 'Travel on the earth and observe it'" demonstrate the importance of empirical observation in the Islamic tradition. Muslim scholars and philosophers have identified several sources of knowledge: the senses, reason, and revelation, each with its own domain and limitations. Al-Ghazali, in his works Ihya Ulumuddin and Al-Munqidz min al-Dalal, discusses the levels of knowledge and how to acquire them in depth. He distinguishes between knowledge acquired through the senses, rational knowledge, and intuitive knowledge or ma'rifah. Although Al-Ghazali criticized philosophers who relied too heavily on reason alone, he did not deny the importance of sensory experience in understanding the physical world. For Al-Ghazali, ultimate truth does indeed come from revelation, but for knowledge of natural phenomena, observation and experimentation play a crucial role. As a defender of the philosophical tradition, Ibn Rushd sought to demonstrate the harmony between revelation and reason, between religion and philosophy. In his work, Fasl al-Maqal, he argued that there is no true conflict between philosophical truth attained

through rational demonstration and revealed religious truth. Ibn Rushd developed a theory of double truth, allowing for the coexistence of philosophical-scientific truth with religious truth. This view allowed for the development of science based on observation and logical reasoning without conflicting with the principles of faith, thus creating an intellectual climate conducive to the advancement of knowledge in the Islamic world (Fahman et al., 2025).

Manifestation of Empirical Principles in Islamic Scientific Tradition

The classical Islamic scholarly tradition demonstrates the systematic application of empirical principles across multiple scientific fields. Ibn al-Haytham, known in the Western world as Alhazen, developed a rigorous experimental method in his optical studies. In Kitab al-Manazir, he rejected speculative theories of vision that lacked empirical support and instead conducted a series of carefully designed experiments to explain the nature of light and the mechanism of sight (Taqiyuddin & Nasution, 2025). His approach involved systematic observation, hypothesis formation, controlled experimentation, and verification of results—procedures that closely resemble the essential steps of the modern scientific method. It shows that Islamic scholarship did not merely preserve inherited knowledge, but actively refined it through disciplined inquiry and empirical validation.

Al-Biruni likewise exemplified a highly advanced empirical approach in geography and astronomy. He carried out precise measurements to determine the circumference of the Earth by combining trigonometric reasoning with astronomical observation. Rather than relying solely on written authorities, he engaged in direct observation and field measurement to confirm, correct, or improve existing knowledge. In Kitab al-Hind, he also displayed an objective ethnographic method by documenting Indian culture through firsthand observation rather than prejudice or stereotype. Al-Biruni's scientific attitude reflects a strong commitment to empirical truth, intellectual honesty, and objectivity, all of which are fundamental to reliable scholarship (Sheikh, 2024).

Jabir ibn Hayyan in chemistry and Al-Razi in medicine also applied systematic experimental methods in their respective disciplines. Jabir developed laboratory techniques such as distillation, crystallization, and sublimation through repeated experimentation, emphasizing direct observation and careful recording of experimental processes. His work reveals an early awareness that scientific knowledge must be tested, replicated, and refined through practice. Al-Razi, meanwhile, used clinical trials in medical practice to compare the

effectiveness of different treatments, carefully recorded symptoms based on patient observation, and differentiated diseases according to their clinical manifestations (Fitroh et al., 2026). These practices indicate that Muslim scientists treated knowledge as something to be verified through experience, not accepted uncritically from inherited authority.

The role of empiricism in Islamic mathematics and astronomy was equally significant, especially in the advancement of theoretical precision through observation. Al-Khwarizmi developed algebra as a systematic branch of mathematics and introduced the decimal numeral system and the concept of zero from India into the Islamic world and later to Europe. Although mathematics is primarily deductive, Muslim mathematicians applied mathematical concepts to practical problems in trade, inheritance, and astronomy, where proposed solutions had to be tested against real conditions. In astronomy, observatories in Baghdad, Damascus, and Samarkand became centers of sustained and organized sky observation. Astronomers such as Al-Battani, Al-Sufi, and Ulugh Beg produced highly accurate tables by observing celestial motion over long periods, while Al-Battani corrected Ptolemaic data through his own measurements (Ferdino et al., 2024). These achievements demonstrate that the progress of Islamic mathematics and astronomy resulted from a productive synthesis of theoretical reasoning and empirical verification.

Application of Empirical Methods in Islamic Medicine and Pharmacology

Classical Islamic medicine exhibited a highly developed empirical tradition, characterized by careful clinical observation, pharmacological experimentation, and systematic medical record-keeping. This tradition demonstrated that medical practice relied not only on inherited texts but also on direct verification of experience in the field. Thus, Muslim physicians built medical knowledge through repeated observation, evaluation of therapeutic outcomes, and the compilation of reliable clinical data.

Ibn Sina, in his Al-Qanun fi al-Tibb (The Code of Medicine), not only compiled medical knowledge from various sources but also presented his own clinical findings in a structured manner. He developed a diagnosis based on physical symptoms, such as pulse rate, body temperature, and urine output, and emphasized the importance of history taking and monitoring the course of events to determine prognosis and appropriate therapy (Khan et al., 2015). Meanwhile, Al-Razi emerged as a pioneer of the experimental approach to medicine and pharmacology, particularly through clinical trials, detailed descriptions of

smallpox and measles, and comparisons of the effectiveness of various treatments based on his empirical experience.

At the institutional level, bimaristans such as Nur al-Din in Damascus and al-Mansuri in Cairo served as centers for evidence-based medical practice and medical education. Doctors conducted clinical rounds, discussed complex cases, and documented therapies and their outcomes, thus cumulatively increasing empirical knowledge. Therefore, classical Islamic medicine can be understood as a scientific tradition oriented toward patient well-being and the development of knowledge based on evidence, not solely on textual authority (Karimaliana et al., 2023).

DISCUSSION

Integration of Revelation and Observation in Islamic Cosmology

Islamic cosmology reflects a distinctive synthesis between revelation and empirical observation. The Qur'an contains many verses describing the creation of the heavens and the earth, the movement of the sun and the moon, and various natural phenomena; for Muslim scholars, these verses were not meant to be understood only literally, but also through observation and rational reasoning. For this reason, cosmology in the Islamic tradition developed as an effort to harmonize the truth of revelation with the findings of astronomy, based on the conviction that both come from the same source: Allah, the Creator of the universe and the giver of revelation (Nurhuda et al., 2026).

From this foundation emerged the concepts of ayat kauniyah and ayat qauliyah, namely Allah's signs manifested in the universe and Allah's signs recorded in the Qur'an. Both are understood as complementary expressions of divine wisdom and power, rather than as mutually exclusive sources of truth. In Ibn Rushd's view, studying nature is a form of worship because through nature human beings come to know the greatness of the Creator. This idea provides a spiritual basis for the development of science, so that empirical observation of the universe is seen not merely as a neutral activity, but as a way of understanding and glorifying Allah.

However, this integration has not always been free from tension. Al-Ghazali, for example, in Tahafut al-Falasifah criticized philosophers who taught the eternity of the universe, as this was considered contrary to the Islamic doctrine of creation. The debate between Al-Ghazali and Ibn Rushd reveals the complexity of the relationship between

philosophy, science, and religion in the Islamic world: there were integrative efforts, but also critiques of the limits of empirical knowledge (Kadir, 2024). Nevertheless, such tensions did not halt the progress of science in the Islamic world; rather, they encouraged deeper reflection on the scope of each source of knowledge and showed that dialogue between religion and science has long been an integral part of Islamic intellectual history.

The Relevance of Empiricism for the Revitalization of Contemporary Islamic Science and Technology

The contemporary Muslim world faces major challenges in science and technology, particularly because its contribution to global scientific knowledge production remains relatively small despite its very large population. This condition reveals a gap between the potential of the Muslim community and its actual achievements in scientific development. Therefore, it is important to revisit the intellectual legacy of classical Islam, especially the Islamic golden age, when Muslim scholars developed an advanced scholarly tradition by combining Islamic values, rationality, and empirical methods (Fahrudin et al., 2020; A. S. Ichsan et al., 2023; A. S. Ichsan & Fathurrahman, 2019; Wijaksono & Ichsan, 2022). From this perspective, scientific progress does not emerge from a rejection of religion, but rather from an open, critical, and truth-seeking intellectual attitude.

One of the key lessons from the classical Islamic scholarly tradition is that scientific advancement requires a commitment to observation, experimentation, and empirical verification, rather than mere reliance on textual authority or established tradition. Earlier Muslim scientists demonstrated the courage to re-examine inherited knowledge, correct errors, and build theories on the basis of evidence. Such an attitude is in harmony with the spirit of Islam, which emphasises reason, the pursuit of knowledge, and the recognition of God's signs in the universe. Thus, empiricism in the Islamic context is not a threat to faith, but a means of deepening one's understanding of the reality of God's creation (Erasmus, 2024).

The revitalization of science and technology in the Muslim world today requires more than technical mastery; it also demands a philosophical understanding of the scientific method, epistemology, and the relationship between knowledge and religion. Science education should be directed not only at producing technically competent graduates, but also at fostering spiritual motivation and ethical commitment to serving society. In addition to

investment in research infrastructure and educational reform, what is most important is the revival of the intellectual spirit of classical Islam: openness to knowledge from diverse sources, commitment to excellence, and dedication to the welfare of humankind. By reawakening the values of empiricism, healthy skepticism, and evidence-based verification, the Muslim world has the opportunity to rebuild a strong, sustainable, and relevant scientific tradition for the challenges of the present age (Syauqi, 2023).

CONCLUISON

This study shows that empiricism, as an epistemological approach grounded in observation, experimentation, and verification, is not foreign to the Islamic intellectual tradition but is deeply reflected in the scientific practices of classical Muslim scholars. The achievements of Ibn al-Haytham, Al-Biruni, Jabir ibn Hayyan, Al-Razi, Ibn Sina, and other Muslim scholars demonstrate that the golden age of Islam was built on a productive synthesis of revelation, reason, and empirical inquiry, which contributed significantly to the advancement of science and technology. This historical legacy also confirms that Islamic epistemology is compatible with empirical methods and can serve as a strong foundation for revitalizing contemporary Muslim scientific development. Therefore, reactivating the spirit of critical observation, rigorous experimentation, and ethical commitment to knowledge is essential for rebuilding a vibrant, relevant, and future-oriented Islamic science tradition.

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