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ISLAMIC CONTRIBUTIONS TO SCIENTIFIC AND TECHNOLOGICAL DEVELOPMENT IN ASTRONOMY, MATHEMATICS, MEDICINE, AND CHEMISTRY

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Abstract

This research discusses the contribution of Islamic civilization to the development of world science and technology and examines the role of Muslim scholars in shaping a scientific paradigm rooted in Islamic spiritual values and rationality. Based on the Eurocentric view dominating scientific historiography, the research gap identifies the urgent need for a comprehensive study that positions the Islamic contribution within an integrative, holistic, and value-based scientific paradigm. The novelty of this study lies in its comparative approach, demonstrating that Islamic scientific development possessed distinct epistemic, methodological, and ethical orientations thereby offering an alternative, ethically-oriented model of science insufficiently explored in previous research. Therefore, the purpose of this study is to reveal how Islam not only served as a medium for the transmission of knowledge from Greek civilization but also as an originator of a rational and ethical scientific method. This study uses a qualitative approach through a literature review by analyzing classical works of Muslim scholars and contemporary literature on the history of Islamic science. The results show that Muslim scholars such as Al-Battani, Al-Khawarizmi, Ibn Sina, and Al-Razi made fundamental contributions in the fields of astronomy, mathematics, medicine, and chemistry. Their contributions were not only technical but also epistemological, emphasizing the integration of revelation and reason as the foundation of knowledge pursuit. These findings indicate that the Islamic scientific paradigm is holistic, oriented

toward public welfare, and rejects the dichotomy between science and religion. The implications of this research highlight the importance of reconstructing the epistemology of Islamic science in contemporary education and research contexts to build a just and sustainable civilization of knowledge. Thus, the reconstruction of Islamic science epistemology is not merely a historical endeavor, but a strategic step to rebuild the orientation of science rooted in the values of monotheism, ethics, and universal welfare.

Penelitian ini membahas kontribusi peradaban Islam terhadap perkembangan ilmu pengetahuan dan teknologi dunia serta menguji peran para ilmuwan Muslim dalam membentuk paradigma ilmiah yang berakar pada nilai-nilai spiritual dan rasionalitas Islam. Berdasarkan pandangan Eurosentris yang mendominasi historiografi ilmiah, kesenjangan penelitian mengidentifikasi kebutuhan mendesak akan studi komprehensif yang memposisikan kontribusi Islam dalam paradigma ilmiah yang integratif, holistik, dan berbasis nilai. Kebaruan dari studi ini terletak pada pendekatan komparatifnya, yang menunjukkan bahwa perkembangan ilmu pengetahuan Islam memiliki orientasi epistemik, metodologis, dan etis yang berbeda, sehingga menawarkan model ilmu pengetahuan alternatif yang berorientasi etis yang belum cukup dieksplorasi dalam penelitian sebelumnya. Oleh karena itu, tujuan dari penelitian ini adalah untuk mengungkapkan bagaimana Islam tidak hanya berfungsi sebagai media transmisi pengetahuan dari peradaban Yunani, tetapi juga sebagai pencetus metode ilmiah yang rasional dan etis. Studi ini menggunakan pendekatan kualitatif melalui tinjauan literatur dengan menganalisis karya-karya klasik para ilmuwan Muslim dan literatur kontemporer tentang sejarah ilmu pengetahuan Islam. Hasil penelitian menunjukkan bahwa ilmuwan Muslim seperti Al-Battani, Al-Khawarizmi, Ibn Sina, dan Al-Razi memberikan kontribusi mendasar dalam bidang astronomi, matematika, kedokteran, dan kimia. Kontribusi mereka tidak hanya bersifat teknis tetapi juga epistemologis, menekankan integrasi wahyu dan akal sebagai fondasi pencarian pengetahuan. Temuan-temuan ini mengindikasikan bahwa paradigma ilmiah Islam adalah holistik, berorientasi pada kesejahteraan publik, dan menolak dikotomi antara sains dan agama. Implikasi dari penelitian ini menyoroti pentingnya rekonstruksi epistemologi ilmu pengetahuan Islam dalam konteks pendidikan dan penelitian kontemporer untuk membangun peradaban pengetahuan yang adil dan berkelanjutan. Dengan demikian, rekonstruksi epistemologi ilmu pengetahuan Islam bukan sekadar upaya historis, melainkan langkah strategis untuk membangun kembali orientasi ilmu pengetahuan yang berakar pada nilai-nilai tauhid, etika, dan kesejahteraan universal.

Keywords: *epistemology, Islamization of knowledge, Muslim scholars, modern science, scientific paradigm*

Introduction

In Islamic tradition, the concept of *'ilm* (knowledge) occupies a fundamental position as the main foundation of civilization. The Qur'an mentions the term 'ilm more than 750 times, indicating how central knowledge is in shaping faith and the progress of humanity (Nasr, 1968). The pursuit of knowledge in Islam is viewed as part of worship and devotion to Allah SWT. According to Al-Ghazali, knowledge is divine light that Allah instills in the hearts of humans to guide them to truth and wisdom (*hikmah*) (Nasution, 2021). The understanding of science in Islam encompasses rational, moral, and spiritual dimensions in an integrated manner, thereby connecting revelation *(wahy)* and reason *('aql)* as sources of knowledge (Siregar & Lubis, 2020). This integrative framework of understanding then opened space for the emergence of a scientific tradition that developed within Islamic civilization.

Islamic civilization played a significant role in the formation of global scientific traditions. The Islamic world was a center of scientific advancement that encompassed spiritual, logical, and empirical aspects between the eighth and fourteenth centuries AD (Nasr, 1968). Thanks to the contributions of Muslim scholars such as Al-Khawarizmi, Ibn Sina, Al-Razi, and Jabir ibn Hayyan, various disciplines ranging from astronomy, mathematics, and medicine to chemistry experienced rapid development during this period. They not only preserved the intellectual heritage of the Greeks, but also enriched and revolutionized scientific methods through observational and experimental approaches (Rashed, 1994).

The *Bayt al-Hikmah*, which emerged during the Abbasid era as a center for translation and the integration of knowledge, became a pivotal milestone in the advancement of the Islamic scientific tradition (Gutas, 1998). The massive translation movement of the works of Aristotle, Galen, and Ptolemy gave birth to new innovations in various fields. For example, in astronomy, Al-Battani and Al-Tusi updated Ptolemy's geocentric model with data-based observation methods (Kennedy, 1983). In mathematics, Al-Khwarizmi introduced the concept of *al-jabr* (algebra) and the decimal system, which form the basis of modern computational logic (Rashed, 1994). Meanwhile, in medicine, Ibn Sina compiled a comprehensive and rational medical system through *Al-Qanun fi al-Tibb*, which became the main reference for the Western world for centuries to come (Pormann & Savage-Smith, 2007) In chemistry, Jabir ibn Hayyan and Al-Razi introduced experimental methods that would later influence the foundations of modern chemistry (Holmyard, 1957).

Although this contribution has been recognized by some scholars, the historiography of modern science is still dominated by a Eurocentric perspective that places Islam merely as an intermediary between Greece and Europe (Huff, 1993). Previous research shows that this approach ignores the methodological dimensions developed by Muslim scientists, especially in terms of experimentation and systematization of knowledge (Nasr, 1968). In addition, there are still limitations in contemporary research that presents the contributions of Islam thematically across disciplines, because most previous studies are partial and do not emphasize the integration between Islamic Sciences and modern scientific practice (Arzaki et al., 2025). This condition indicates the presence of a research gap in the form of a need for a comprehensive study that positions the contribution of Islam within an integrative, holistic, and value-based scientific paradigm, rather than as merely a technical inheritance from previous civilizations.

The novelty of this study lies in a comparative approach that not only traces the historical contributions of Muslim scholars, but also demonstrates how the development of science in the Islamic world possessed epistemic, methodological, and ethical orientations distinct from those of the Western scientific tradition. While Western science evolved through secular, mechanistic, and utilitarian paradigms during the Renaissance and the Scientific Revolution, the Islamic intellectual tradition was rooted in the integration of rationality, spirituality, and human welfare (Soelaiman, 2019). Thus, this study offers a new perspective that reveals how Islamic civilization not only provided the foundational knowledge for the West, but also presented an alternative model of science oriented toward tawhid, ethics, and sustainability, an aspect that has not been sufficiently explored in previous research.

In a global era characterized by the dominance of secular and utilitarian science, the study of integrating Islamic values into the development of scientific knowledge has become increasingly relevant and significant. This is not only important historically, but also epistemologically, because Islam offers a scientific paradigm oriented towards the search for divine truth (al-haqq) and universal benefit (*maslahah*) (Dallal, 2010). This study also challenges the dichotomous view between science and religion that often arises in modern discourse, by emphasizing that in Islam, knowledge (*'ilm*) is a spiritual instrument for understanding the order of God's creation (Sofyan et al., 2021).

Thus, this study aims to fill the scientific gap in Islamic science studies with a holistic approach that systematically examines the contributions of Islam

in four main fields, namely astronomy, mathematics, medicine, and chemistry. It is expected to provide a new perspective on how Islamic epistemology not only contributed to the historical development of science but also offered an ethical and philosophical basis for the development of contemporary science. Specifically, this study seeks to explore the significant influence of Islamic civilization on the development of global science and technology, as well as to examine how Muslim scholars contributed to shaping the foundations of the modern scientific paradigm through the integration of rational inquiry and Islamic spiritual principles.

Method

This study employs a Systematic Literature Review (SLR) design with a descriptive-qualitative approach, which involves systematically examining, selecting, and synthesizing classical and contemporary literature on the contributions of Islamic civilization to the development of science and technology. This method was chosen because it focuses on analyzing various sources and literary texts to reveal how Islamic civilization advanced science and technology, especially in the fields of chemistry, astronomy, mathematics, and medicine.

The subjects of this study are the works of classical Muslim scientists such as Al-Khawarizmi, Ibn Sina, Al-Razi, Al-Biruni, Al-Battani, Jabir Ibn Hayyan, and other Muslim scholars, as well as modern research discussing their scientific legacy. The research procedure was carried out through the following stages: (1) determining the focus of the study and the formulation of the problem; (2) collecting relevant literature; (3) selecting primary and secondary sources; (4) conducting content analysis of the data; and (5) compiling the findings to draw conclusions.

The research materials and instruments were documents, books, and scientific articles relevant to the topic of study. The researcher acts as the main instrument in critically interpreting and analyzing the data. This research documentation method, which involves reviewing various leading scientific publications, is used to collect data. The content analysis approach, which combines data reduction, information presentation, and conclusion drawing to produce a comprehensive and in-depth picture, is used to carry out the data analysis procedure.

Finding and Discussion

Islamic Civilization and Science

Islamic culture made a significant contribution to the advancement of global science and technology between the seventh and sixteenth centuries. During this period, the Islamic world developed into a major center of scientific activity and technological innovation, making a major contribution to human progress. The Islamic Golden Age, spanning from the eighth to the fifteenth century, particularly during the Abbasid era in Baghdad and the Islamic rule in Andalusia, reflects the peak of scientific achievement and the flourishing of Islamic civilization. Islamic culture showed remarkable progress in a well-structured education system throughout its heyday, thanks to various institutions such as madrasas, mosques, and *bimaristans*, or educational hospitals (Azra, 2012). In addition to serving as centers of religious instruction, madrasas were also scientific institutions that advanced various fields of study, including chemistry, philosophy, mathematics, astronomy, and medicine.

In this era, the Islamic world experienced a remarkable intellectual revival with the establishment of various scientific institutions such as Bayt al-Hikmah, madrasas, observatories, and large libraries in Islamic city centers (Saliba, 2007). The translation of Greek, Persian, and Indian intellectual writings into Arabic was greatly aided by Bayt al-Hikmah. However, Muslim scientists did not stop at translation alone but developed new theories and methods in various disciplines, including astronomy, mathematics, medicine, and chemistry (Arzaki et al., 2025). *Al-Qanun fi al-Tibb*, a fundamental work by Ibn Sina, became the primary medical text for centuries; Ibn Rushd made significant contributions that laid the foundation for the emergence of modern science through his philosophical thinking; and great scientists such as Al-Khawarizmi introduced the concepts of algebra and the decimal number system (Alinata et al., 2024).

When the works of Muslim scholars were translated into Latin and used as primary references in a number of European universities and educational institutions, the influence of the Islamic education system on the advancement of Western culture became increasingly apparent (Kosasih, 2024). Knowledge from the Islamic world reached Europe through open intellectual contact in Sicily and Andalusia, where Muslims, Christians, and Jews interacted in a comparatively open scholarly climate, which contributed to the Enlightenment. In these territories, the translation of Arabic scientific texts covering astronomy, mathematics, medicine, philosophy, and optics into

Latin became one of the most significant channels of knowledge transmission. Muslim scholars in medieval Andalusia, in particular, played a central role in refining astronomical instruments, advancing observational methods, and producing precise astronomical tables that were later used across Europe. As noted by Mujani and Ibrahim (2012), Andalusian astronomers developed sophisticated star catalogues, improved the astrolabe, and introduced mathematical techniques that later underpinned European astronomical advancements (Mujani, 2012).

These intellectual exchanges did not occur in isolation; they shaped the curricula of emerging European universities and stimulated critical inquiry during the High Middle Ages. The influx of Aristotelian philosophy preserved and commented on by Muslim philosophers like Ibn Rushd (Averroes) reoriented Western scholasticism toward empirical reasoning. Over time, these translated works and scientific advancements contributed to the intellectual groundwork for the Renaissance, eventually influencing the scientific revolution and the Enlightenment. Thus, the Andalusian and Sicilian knowledge routes served not merely as channels of transmission but as catalytic spaces where scientific ideas were transformed, debated, and expanded, enabling Europe to integrate Islamic scientific heritage into its own trajectory of intellectual development. This shows that in addition to maintaining the continuity of knowledge, the Islamic education system was a major force behind the growth of a scientific heritage based on reason and empirical research. Thus, Islamic education in the Middle Ages was an important element that accelerated intellectual change in the Western world.

Islamic education emphasizes the importance of equal access to knowledge, where every individual has the right to obtain learning opportunities regardless of gender or social status. There were many opportunities for women to participate in academic activities at madrasas and other Islamic educational institutions. Fatimah al-Fihri, the founder of the University of Al-Qarawiyyin in Morocco, recognized as one of the oldest universities in the world, represents a historical example of the contribution of Muslim women to the development of knowledge (Sairah, 2023). The European education system, which had previously been closed and only available to certain groups, was then greatly influenced by these egalitarian and inclusive ideals.

When early European universities, including the University of Bologna and the University of Paris, adopted institutional structures and teaching practices similar to those of the madrasah system, it became increasingly clear

how Islamic education influenced the development of Western education (Abidin & Haddade, 2024). The tradition of Islamic education influenced learning styles that emphasize critical textual study, intellectual mentoring of students, and open discussion. These concepts were brought back to Europe and refined in a regional context by European thinkers who studied in Andalusia and Sicily.

Beyond its scientific achievements, Islam made a significant contribution to education. It established the foundations for a contemporary education system that values common sense, interdisciplinary collaboration, and the pursuit of lifelong learning. This intellectual legacy played a major role in encouraging the revival of thought in Europe, which ultimately gave rise to the Enlightenment (Sihaloho, 2023).

The Islamic education system at that time developed an open and collaborative scientific culture. Madrasas and libraries functioned not only as centers of religious learning, but also as arenas for scientific research and discussion that fostered critical thinking among scholars and students (Sofyan & Supriyadi, 2022). During the golden age of Islam, madrasas developed into educational institutions that taught various subjects, including chemistry, mathematics, medicine, philosophy, and astronomy, in addition to religious knowledge (Berliana, 2024). In a conducive intellectual environment, Muslim scientists produced monumental works that had a major influence and were later used as references by Western scholars. The dissemination of knowledge from the Islamic world to Europe occurred through various channels, particularly Andalusia and Sicily, which served as centers for the translation of Muslim scientific works into Latin, thereby contributing to the birth of the Renaissance movement in Europe (Erzad & Suciati, 2018).

The province of Al-Andalus, known as Spain during the Islamic period, served as one of the main channels for the spread of Islamic knowledge to the West (Mubadillah, 2024). During the Umayyad Dynasty (711–1492), Cordoba became one of the most important centers for Islamic scholarship. The city was famous for its extensive library, which housed thousands of books on various scientific subjects, including philosophy, astronomy, mathematics, and medicine. Many European scholars, especially those from Christian areas of the Iberian Peninsula, came to Cordoba to study and access various sources of knowledge. Translation into Latin was the main means of spreading Islamic knowledge throughout Western Europe.

Through various interactions that developed during the Crusades (1096–

1291 AD), knowledge was also transferred from the Islamic world to the West (Dahlan, 2024). The battle for land in the Middle East was the main objective of the conflict, but it also inadvertently opened the door to intellectual and cultural contact between Europe and the Islamic world. Muslim professors taught various subjects, including astronomy, mathematics, and medicine, to European soldiers during the conflict. Many Crusaders brought this new knowledge back to their home countries, where it then developed and made a substantial contribution to the advancement of science in the West.

Thus, Islamic civilization not only served as a preserver of classical knowledge, but also as the initiator of a new scientific paradigm that integrated faith and rationality. Scientific progress in Islam was rooted in spiritual values that encouraged humans to understand God's creation through research and observation of nature (Siregar & Lubis, 2020).

Islamic Contribution to Astronomy: Observational Tools and Models

Through the contributions of prominent scientists such as Al-Battani and Ibn al-Shatir, who successfully developed fundamental ideas and highly accurate astronomical calculation tools, the Islamic education system played an important role in the field of astronomy (Susanto, 2020). With his precision in compiling astronomical tables, Al-Battani was known to surpass previous scientists, and his work influenced European astronomers, including Copernicus, in the development of the heliocentric theory. He also made significant corrections to the value of the ecliptic inclination and the duration of the solar year with remarkable accuracy.

By creating a more accurate model of the moon and planetary motion, Ibn al-Shatir made a significant contribution that ultimately became the basis for Copernicus's theory of astronomy. The development of theory was not the only aspect of the advancement of Islamic astronomy education, but also included scientific technological innovations through the creation of various instruments, such as the astrolabe and quadrant, which played an important role in the advancement of navigation and global exploration.

The advancement of Islamic astronomy was characterized by rigorous observational practices, systematic mathematical calculations, and critical evaluation of inherited Greek models (Shuriye, 2011). Scholars such as Al-Battani and Al-Biruni refined astronomical tables, corrected planetary measurements, and introduced more precise trigonometric techniques, thereby improving the calculation of celestial motions. Shuriye (2011) also highlights that Ibn al-Shatir's

revision of the Ptolemaic system, particularly the geometric restructuring of planetary orbits, represented an important scientific breakthrough within the Islamic astronomical tradition.

Ibn al-Shatir was one of the key figures in the development of planetary theory during the golden age of Islamic astronomy because he restructured the Ptolemaic model by eliminating the equant and reorganizing the epicycle system, resulting in a geometric construction that aligned more closely with observational data (Saliba, 1995). Although his model remained within a geocentric framework, Ibn al-Shatir's mathematical approach demonstrated significant advancements and exhibited structural similarities to the planetary motion model that later appeared in the work of Copernicus, thereby indicating an intellectual continuity within the astronomical tradition. Meanwhile, Ulugh Beg stands out as a pioneer of institutional observational astronomy through the establishment of the Samarkand observatory and the compilation of the *Zij-i Sultani*, a star catalog and set of astronomical tables produced using large-scale instruments with a high degree of accuracy. From Saliba's perspective, the achievements of Ulugh Beg demonstrate that Islamic astronomy in the fifteenth century did not experience decline, but instead attained a level of observational precision and data processing that provided a foundation for subsequent developments in astronomy (Saliba, 1995).

Muslim scientists such as Al-Battani, Al-Biruni, and Al-Tusi made major contributions to the field of astronomy through accurate observations and the development of theories on the motion of celestial bodies. Al-Battani also corrected Ptolemy's data on the movement of the sun and moon; Al-Tusi created the Tusi Couple model, which Copernicus later used in his heliocentric theory (Tracy, 2020). In addition, Al-Biruni introduced a method for measuring the radius of the earth with a high degree of accuracy (Nasution, 2019).

Instruments such as the astrolabe, quadrant, and the Maragha observatory are clear evidence of Muslim scientists' ability to develop observational devices. These findings demonstrate the continuity between Islamic science and modern astronomy, while also confirming that Islam did not merely inherit Greek science but perfected it (Sofyan et al., 2021).

Islamic Contribution to Mathematics: Algebra and Numeral Systems

The most influential contribution of Islamic civilization in the field of mathematics is reflected in the work of Muhammad ibn Musa al-Khawarizmi, the pioneer of the concept of *al-jabr* (algebra) and the decimal number system.

Al-Daffa (2020) emphasizes that through the use of zero, the adoption of a place value system, and systematic methods for solving linear and quadratic equations, Al-Khawarizmi transformed mathematics from simple arithmetic practice into a scientific discipline that is deductive, structured, and applicable (Al-Daffa, 2020). This transformation not only strengthened the framework of mathematical reasoning but also marked a key milestone in the emergence of algorithmic methods that have significantly shaped modern mathematics and computational technology. *Al-Kitab al-Mukhtasar fi Hisab al-Jabr wal-Muqabalah*, his important work, became an important basis for the advancement of symbolic mathematics and contemporary algorithms (Kamalkhani, 2021). In addition to highlighting theoretical elements, Al-Khawarizmi's work placed strong emphasis on real-world applications related to everyday life, such as land surveying, trade, and inheritance calculations. In the twelfth century, his writings were translated into Latin, allowing his algebraic ideas to spread throughout Europe and become an important foundation for the advancement of contemporary mathematics. The term *al-jabar* that he introduced later evolved into the word "algebra" in English. The influence of Al-Khawarizmi's thinking did not stop in the realm of theory, but also inspired the application of algebraic principles in the fields of astronomy, architecture, and physics, which ultimately became one of the important triggers for the scientific revolution in Europe (Nurhuda, 2022).

Other Muslim mathematicians such as Omar Khayyam, Abu al-Wafa' al-Buzjani, and Al-Kashi also made significant contributions to the development of mathematics through approaches that integrated arithmetic and algebra (Roshdi Rashed, 1994). Omar Khayyam is known for his efforts in classifying and solving cubic equations using innovative geometric methods, which demonstrated an important transition from rhetorical algebra toward more systematic formulations. Meanwhile, Abu al-Wafa' al-Buzjani added an essential foundation to trigonometry through the compilation of more accurate sine tables and the formulation of trigonometric identities that later became references in astronomical calculations. As for Al-Kashi, he demonstrated remarkable precision in numerical computation and refined decimal approximation methods, including achievements in determining the value of π with a level of accuracy not previously attained in his era, thereby strengthening the connection between computational arithmetic and practical algebra within the Islamic mathematical tradition. Furthermore, Muslim scholars such as Nasir al-Din al-Tusi and Al-Biruni created spherical geometry

and trigonometry, which were used for maritime navigation and to determine the orientation of the qibla (Erzad & Suciati, 2018).

This study supports Tracy's findings that the integration of religion and science promotes the advancement of applied mathematics in Islamic architecture, such as the geometric symmetry designs in the Umayyad Mosque and the Taj Mahal (Tracy, 2020). Thus, this achievement shows that Muslim scientists did not merely preserve the Greek legacy, but transformed the mathematical paradigm into a more abstract, deductive, and applicable one, which greatly influenced the evolution of Western science.

Islamic Contribution to Medicine: Clinical Practice and Pharmacopoeia

The Islamic education system has successfully produced a number of important medical works that greatly influenced the advancement of science in the West (Hermawansyah, 2024). Ibn Sina (Avicenna) became famous in the field of Islamic medicine thanks to his important work *Al-Qanun fi al-Tibb* (The Canon of Medicine), which for many years was the main medical textbook in European universities. Ibn Sina successfully combined his own scientific discoveries with Greek medical knowledge, including the theories of Galen and Hippocrates. He popularized the use of standardized herbal medicine, the idea of symptom-based diagnosis, and the basics of clinical trials. His views on human anatomy and blood circulation also enriched Western medicine. Furthermore, experience-based learning in teaching hospitals (*bimaristan*) was prioritized in the Islamic medical school system. This ultimately became the foundation for the creation of the contemporary clinical education model in the West.

Scientists such as Ibn Sina (Avicenna), Al-Razi (Rhazes), and Al-Zahrawi (Abulcasis) revolutionized medical practice around the world. Ibn Sina's monumental work *Al-Qanun fi al-Tibb* became a medical reference in European universities until the seventeenth century, while Al-Razi's *Kitab al-Hawi* combined theory with clinical observation (Nasution, 2019). Al-Zahrawi pioneered modern surgery by creating more than 200 surgical instruments and systematically documenting medical procedures (Sofyan et al., 2021).

In the study of the history of Islamic medicine, Savage-Smith (2013) emphasizes that Al-Zahrawi not only developed surgical practices but also introduced procedural standards that became references in the European medical tradition (Smith & Lindberg, 2013). Another highly significant discovery came from Ibn al-Nafis, who corrected the views of Galen and

Avicenna regarding cardiac anatomy and proposed the theory of pulmonary circulation, a finding that long preceded William Harvey in the Western medical tradition. Savage-Smith (2013) identifies the contribution of Ibn al-Nafis as one of the greatest leaps in the history of physiology due to his observation-based approach and rational argumentation. In addition, Ibn al-Haytham also made important contributions through optical studies and experimental methodology that influenced the development of ophthalmology and subsequent medical research. Savage-Smith (2013) highlights that Ibn al-Haytham's empirical approach became the foundation for the modern scientific method later adopted in Western medical research.

The Islamic approach to medicine is holistic, emphasizing balance between the physical, mental, and spiritual, in contrast to the mechanistic approach of medieval Europe. This connection between science and spirituality is a hallmark of Islamic epistemology, which views health as part of worship and the welfare of the people (Erzad & Suciati, 2018).

Islamic Contribution to Chemistry: Experimentation and Applications

Islamic education played an important role in the subject of chemistry, particularly thanks to the work of Al-Razi (Rhazes), who is considered a pioneer in the use of scientific methods in this discipline (Putri, 2023). Al-Razi developed a systematic experimental approach using methods such as distillation, crystallization, and evaporation through books such as *Kitab al-Asrar* and *Al-Hawi*. These methods later became the foundation for the advancement of modern chemistry. He also succeeded in discovering a number of important substances, such as ethanol, sulfuric acid, and various metals with a variety of uses in industry and medicine. One of the significant intellectual legacies that contributed to the emergence of the Renaissance and the Scientific Revolution was the Islamic educational tradition, which promoted values such as careful observation, documentation of experimental findings, and scientific verification. These values also encouraged Western scientists to develop a more methodical scientific approach.

The field of chemistry in Islam flourished thanks to Jabir ibn Hayyan (Geber), known as the Father of Modern Chemistry. He introduced the concepts of systematic experimentation, the use of laboratories, and the methods of distillation and sublimation for purifying substances (Tracy, 2020). Jabir was also the first scientist to distinguish between acids and bases and to write down laboratory procedures methodologically. Jabir is also considered

the first scientist to emphasize the importance of laboratories as controlled experimental spaces (Sofyan et al., 2021).

These findings show that Islamic chemistry was based on empirical observation and replication of results long before the birth of modern chemistry in Europe. This rigorous methodological foundation established by scholars like Jabir ibn Hayyan provided the experimental principles that would later become central to scientific inquiry globally. Research by Sofyan et al. (2021) confirms that Jabir's work was translated into Latin in the 12th century and inspired Western scientists such as Roger Bacon and Paracelsus (Sofyan et al., 2021).

Integration of Islamic Values in Science

In Islam, knowledge is never separated from religious teachings. The concept of integrating Islamic values into science emphasizes that worldly knowledge and religious knowledge are complementary to one another. Islam views knowledge as part of faith and a means to know and draw closer to Allah SWT. The Qur'an repeatedly encourages humans to think, research, and reflect on Allah's creations as signs of His greatness. Therefore, seeking knowledge is not merely an effort to fulfill one's needs in life or career, but also a form of devotion and worship to God. Knowledge in Islam must grow on the foundation of monotheism, morality, and the benefit of humanity.

Philosophically, the integration between Islam and science is based on three main pillars: *tawhid, khilafah*, and *akhlak*. First, the principle of *tawhid* affirms that all knowledge comes from Allah as the owner and giver of knowledge. Nature and its laws are manifestations of Divine will and wisdom. Therefore, the scientific activities of a Muslim are essentially a process of reading the signs of God in the universe. Second, the principle of *khilafah* places humans as Allah's representatives on earth with the responsibility to preserve and manage resources wisely. Science becomes an instrument to carry out this mandate, not a means of exploitation. Third, the principle of *akhlak* serves as an ethical guideline so that science is used responsibly and honestly. Values such as scientific integrity, social empathy, and concern for human welfare are the foundations of scientific activity.

This concept rejects secularism, which separates religion from science. In modern Western tradition, science is often considered value-free, whereas in Islam, science is always linked to moral and spiritual goals. Seyyed Hossein Nasr argues that the modern humanitarian crisis and ecological damage are

the result of the disconnect between science and spirituality (Dharma, 2024). Islam offers a solution by integrating rationality and spirituality so that scientific development does not neglect human values. Thus, science must play a role in upholding social justice, maintaining the balance of nature, and strengthening human faith in the Creator.

The implementation of Islamic values in science is evident in the education and scientific research systems in the Islamic world. Education should prioritize moral and spiritual development in addition to mastery of cognitive skills and reasoning. Muslim scientists need to be aware that every piece of research has ethical and social responsibilities. In medicine, for example, research must respect human dignity and avoid harmful actions without justifiable reasons. In economics, the application of sharia principles is directed at creating social justice and mutual prosperity. Similarly, in the fields of technology and the environment, Islamic values serve as guidelines so that progress does not cause damage to Allah's creation.

Furthermore, this idea of integration has given rise to various thoughts from contemporary Muslim scholars. Some scholars advocate a full-scale Islamization (or integration) of knowledge reconstructing modern disciplines so their epistemological foundations and ethical aims align with Islamic worldview and values, rather than merely appending religious content to secular curricula. This approach associated with thinkers such as Ismail Raji al-Faruqi introduced the concept of Islamization of knowledge, which aims to restore the orientation of science to Islamic values so that science can develop in a civilized manner (Al-Arifi, 2023). This idea was expanded upon by Syed Naquib al-Attas, who emphasized the concept of ta'dib or moral education as the core of the scientific process (Utami, 2023). This approach aligns with the analysis of Azmi and Nadia (2022), who argue that integration is not merely the addition of religious content but a reformulation of the foundational values and epistemic orientation of knowledge itself (Fakhruddin Azmi, 2022). Meanwhile, contextual models of integration are developed through research in science education, such as those by Schreiber (2024), which demonstrate that Islamic values can be internalized into curricula and teaching practices without compromising the methodological rigor of modern science (Schreiber & Wagner, 2024).

In addition to epistemological and pedagogical approaches, a number of studies also highlight the historical and structural aspects of scientific development in the Muslim world. Mehfooz and Syed (2020) comprehensively

map the various factors that have contributed to the scientific and technological lag in Muslim societies from the impacts of colonialism and weak national policies to limited research investment and offer recommendations such as strengthening research infrastructure and improving scientific governance (Mehfooz, 2020). Their findings align with the Islamic Development Bank (2020) report, which emphasizes the urgency of science policy reform, enhanced international collaboration, and increased research capacity among member states (Islamic Development Bank, 2019). Recent analyses of R&D spending in the GCC region (Benlaria et al., 2023) further reinforce the argument that research investment without proper management strategies contributes to weak scientific output (Benlaria et al., 2023).

Mehfooz and Syed (2020) elaborate on this historical diagnosis and propose practical steps, including strengthening research infrastructure, expanding international collaboration, and reforming science policies capable of bridging the roles of religious institutions with national development needs (Mehfooz, 2020). In addition, the literature reflects methodological and normative debates: to what extent integration should be pursued (whether reconstructive or incorporative), which Islamic sources ought to serve as the foundation for scientific ethics, and how its success should be measured—whether through academic output, social impact, or moral formation.

These diverse discourses have produced a range of concrete proposals, from the development of textbooks and integrated curriculum models to national-level science governance strategies grounded in Islamic ethical principles. Overall, this intellectual movement suggests that "integration" is not a single, uniform program but rather a plural, dynamic, and contested discursive field with both theoretical and practical dimensions. Thus, the integration of Islamic values is not merely adding religious arguments to scientific theory, but building an epistemological framework that unites reason and revelation in understanding reality.

The application of this principle gave rise to Muslim scientists who were not only intellectually intelligent, but also moral, spiritual, and socially responsible. They did not stop at empirical truth, but sought moral and transcendental truth. History proves that figures such as Al-Biruni, Ibn Sina, Al-Khwarizmi, and Jabir ibn Hayyan were able to develop modern science without abandoning the Islamic values that were the foundation of their lives. For them, science was not merely an academic achievement, but also a means of worship and devotion.

Therefore, the integration of Islamic values in science is the main foundation for building an Islamic civilization that balances technological progress and spirituality. Science should not be free from values, but should side with humanity and divinity. This concept shapes the perfect human being (*insan kamil*)—a person who is knowledgeable, faithful, and noble in character. In the current global context, this approach is highly relevant for creating a just and sustainable civilization, where science is used as a means to glorify life, not to destroy it.

The scientific paradigm of Islam is monotheistic, viewing all branches of science as a means to understand the greatness of God. Consequently, scientific pursuits are often guided by ethical frameworks derived from faith, ensuring that knowledge benefits humanity without causing harm. Therefore, the orientation of research is not only on technological advancement, but also on the welfare and balance of human life (Erzad & Suciati, 2018).

The findings of this study indicate that Islamic civilization significantly advanced global science and technology, particularly in the fields of chemistry, astronomy, mathematics, and medicine. Based on literature reviews and historical evidence, Muslim scientists did not merely pass on Greek and Persian knowledge, but actively developed new methods based on experimentation and scientific observation (Kamalkhani, 2021).

These findings are in line with the previously formulated research objectives, namely to describe the substantive contribution of Islamic civilization to the development of world science. From the results of the analysis, it appears that the Islamic scientific paradigm is rooted in the synthesis of reason and revelation (*aql* and *naql*), which places scientific activity as an integral part of worship and an expression of the search for divine truth.

Methodologically, these results confirm that the Islamic scientific tradition fostered the principles of empirical observation and logical reasoning, two main pillars of the modern scientific method. This conclusion is in line with the findings of Sofyan et al. (2021), which show that Muslim scientists had built laboratories, observatories, and systematic analysis systems long before the emergence of the Scientific Revolution in the West (Sofyan et al., 2021).

However, there are differences in interpretation among historians regarding the level of originality of Muslim scientists' innovations. Some Western studies consider them to be successors to the classical Greek tradition. In contrast, Muslim scholars emphasize the epistemological and methodological innovations that emerged from the Islamic context itself.

The limitations of these findings lie in the scarcity of primary sources, as most classical scientific manuscripts have not been fully translated and are still stored in ancient Islamic libraries. Therefore, future research should focus on philological studies and the digitization of Islamic scientific manuscripts in order to gain a more comprehensive understanding of the contributions of Muslim scientists to the history of world science as summarized in table 1.

Table 1. Major Contributions of Muslim Scholars to Science and Technology

Discipline	Prominent Scholar	Main Contributions	Impact on Modern Science
Astronomy	Al-Battani, Ibn al-Shatir, Al-Biruni, Ulugh Beg, Al-Tusi	Astronomical tables, observatory models	Foundation for celestial mechanics
Mathematics	Al-Khawarizm Omar Khayyam, Abu al-Wafa' al-Buzjani, Al-Kashi	Al-gebra, algorithms	Basis for computational systems
Medicine	Ibnu Sina, Al-Razi, Al-Zahrawi, Ibn al-Nafis, Ibn al-Haytam	Clinical methods, hospitals	Standardization of medical science
Chemistry	Al-Razi, Jabir Ibn Hayyan	Laboratory methodology, distillation	Foundation for experimental chemistry

Conclusion

This study aims to examine the role of Islamic civilization in advancing global science and technology, while also exploring the contributions of Muslim scientists in establishing the foundations of the modern scientific paradigm based on Islamic spiritual values and rationality. Based on the results of literature reviews and historical analyses that have been conducted, it can be concluded that Islam not only played a role as an intermediary in transmitting Greek knowledge to the West, but also as a pioneer in giving birth to systematic, rational, and empirical scientific methods. Thus, Islamic civilization has provided the epistemological and ethical foundations for the birth of modern science.

Substantively, the results of the study show that science in the Islamic view is integral, combining revelation (*naqli*) and reason (*'aqli*) as the two main

sources of knowledge. Muslim scientists place scientific activity as a form of worship and a means of getting closer to Allah SWT. This Islamic scientific paradigm rejects the dichotomy between religion and science, and instead emphasizes *tawhid* as an epistemological foundation that directs science towards *maslahah* (benefit) and *al-haqq* (divine truth). This approach distinguishes Islamic science from modern secular science, which tends to separate spiritual values from the scientific process.

The contributions of Islamic civilization were multidimensional, forming the foundation of modern science. In astronomy, scholars like Al-Battani and Al-Tusi created accurate models of celestial motion through mathematical calculations, later inspiring the heliocentric theory. Mathematics was profoundly enriched by Al-Khwarizmi, who introduced the concept of *al-jabr* (algebra) and the decimal number system, establishing modern computational logic. In medicine, the works of Ibn Sina (*Al-Qanun fi al-Tibb*) and Al-Razi pioneered symptom-based diagnosis, clinical trials, and medical ethical standards, complemented by the surgical innovations of Al-Zahrawi. Chemistry, initiated by Jabir ibn Hayyan, established empirical methods, documentation, and techniques like distillation, which became the basis of modern chemistry in Europe.

Reflection on the results of this study shows that Islamic epistemology has a holistic and benefit-oriented character, in contrast to the Western positivistic approach, which tends to be mechanistic and value-free. The Islamic scientific tradition has established a system of education, research, and observation that emphasizes ethics, scientific integrity, and social responsibility. This legacy remains relevant today in addressing humanitarian crises, moral degradation, and ecological damage caused by technological developments that are not grounded in spiritual values.

From an academic contribution perspective, this research expands the study of Islamic science historiography with an interdisciplinary and integrative approach, highlighting the relationship between Islamic epistemology, scientific methodology, and the ethical dimensions of science. The novelty of this study is that Islam forms a paradigm of science based on *tawhid* (monotheism) that is capable of uniting faith, reason, and empiricism within a single scientific framework. This paradigm can serve as a conceptual alternative in constructing a contemporary model of science that is ethical, sustainable, and equitable.

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