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Research Article

The Role of Muslim Scientists in the Development of Experimental Science and Materials Studies: *A Systematic Literature Review*

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Abstract: *The development of modern experimental science is inseparable from the significant contributions of Muslim scientists during the golden age of Islamic civilization. Muslim scientists played a crucial role in transforming speculative approaches into a scientific tradition based on empirical observation, laboratory experiments, material analysis, and systematic scientific documentation. However, studies on the contributions of Muslim scientists to the development of experimental science and materials studies remain fragmented and dominated by historical-descriptive approaches. This study aims to systematically identify, evaluate, and synthesize scientific literature related to the role of Muslim scientists in the development of experimental science and materials studies. This study used a Systematic Literature Review (SLR) approach with the PRISMA 2020 protocol and the PICOS framework to ensure transparency and rigor in the literature selection process. The review was conducted on 40 selected articles published between 2020 and 2025 from reputable international databases such as Scopus, Web of Science, ScienceDirect, SpringerLink, and JSTOR. The analysis was conducted using a thematic synthesis approach to identify key themes, theoretical developments, methodological approaches, and contextual patterns in the literature. The research findings show that Muslim scientists made significant contributions to the development of experimental science through the development of laboratory methods, empirical observation, material classification, and experimental procedures that became the foundation of the modern scientific method. Figures such as Jabir ibn Hayyan contributed significantly to the development of experimental chemistry through distillation, crystallization, sublimation, and filtration techniques. Meanwhile, Al-Razi and Al-Biruni made significant contributions in the fields of pharmacy, mineralogy, material analysis, and scientific experimentation. This study also demonstrates that the Islamic scientific tradition integrates empirical observation, rationality, and spiritual values in the development of science.*

Keywords: Muslim Scientists, Experimental Science, Materials Studies, Islamic Civilization

1. Introduction

The development of modern science is inextricably linked to the significant contributions of Islamic civilization in building the foundations of experimental-based science. Throughout the history of scientific development, Muslim scientists played a strategic role in transforming the speculative philosophical tradition into an empirical approach emphasizing observation, experimentation, verification, and the systematization of knowledge. This scientific tradition flourished during the golden age of Islamic civilization and served as a crucial bridge in the transmission of knowledge from the classical world to modern science. In this context, the contributions of Muslim scientists were not limited to theoretical aspects but also included the development of experimental methods and the study of materials, which became essential foundations for the development of modern chemistry.

The study of the contributions of Muslim scientists to the development of science has again received attention in recent years, particularly in discourses on the integration of science, the history of science, and the development of contemporary Islamic epistemology. Recent research has shown that Islamic civilization made significant contributions to the development of scientific methodology based on empirical observation and laboratory experimentation (Antoni et al., 2025). In chemistry, for

example, figures such as Jabir ibn Hayyan are known as pioneers of the experimental method through the development of distillation, sublimation, crystallization, evaporation, and various laboratory procedures that remain fundamental to modern chemical practice. These contributions demonstrate that Muslim scientists not only inherited ancient Greek knowledge but also made significant methodological advancements.

Furthermore, the development of materials studies in Islamic civilization also marked a significant milestone in the history of science. Studies on metals, minerals, pharmaceuticals, dyes, glass, ceramics, and even medical materials developed through a systematic empirical approach. Research on the thought of Jabir ibn Hayyan shows that the concept of chemistry in the Islamic tradition was not merely metaphysical, as in classical alchemy, but began to shift toward a rational and applicable experimental approach to materials (Faniyah & Hidayatullah, 2021). In this context, the development of materials science in the classical Islamic era became a crucial foundation for the development of modern materials science.

The epistemological transformation of science in Islamic civilization was also influenced by the Qur'anic paradigm, which encourages observation of the universe. Several recent studies have shown that the Kauniyah verses in the Qur'an served as intellectual inspiration for the development of science and technology during the Islamic civilization era (Antoni et al., 2025). This paradigm gave birth to a scientific tradition that combines spirituality, rationality, and empirical experimentation in scientific activities. Therefore, the development of science in Islamic civilization cannot be separated from the construction of Islamic epistemology, which places the pursuit of knowledge as part of worship and the development of civilization.

In the context of chemistry, the contributions of Muslim scientists are crucial because many laboratory techniques used today have historical roots in the experiments of Muslim scientists in the Middle Ages. Various studies indicate that Muslim scientists successfully developed laboratory equipment, methods for purifying substances, techniques for separating materials, and testing compounds, which later became the foundation for the development of modern experimental chemistry. In fact, several concepts in pharmacy, metallurgy, and mineralogy developed through systematic experiments conducted by Muslim scientists in centers of Islamic learning such as Baghdad, Damascus, Cairo, and Cordoba.

Although the contributions of Muslim scientists to the development of science have been widely discussed in various studies, the available literature remains fragmented. Most studies focus solely on general historical aspects without systematically synthesizing the contributions of Muslim scientists to the development of experimental science and comprehensive materials studies. Other studies focus more on the integration of Islamic values into modern science education than on analyzing the empirical contributions of Muslim scientists to the development of experimental methodology and materials science. This situation indicates a significant gap in the literature.

Furthermore, studies on the relationship between the development of experimental science in Islamic civilization and its relevance to the development of modern chemistry and materials science are still relatively limited. Most studies fail to explain how the experimental methods developed by Muslim scientists contributed to the formation of the modern scientific method. Yet, the experimental approach developed in Islamic civilization was a crucial milestone in the evolution of global scientific epistemology.

Current literature also shows that discussions of Muslim scientists in the history of science are often descriptive and do not utilize a systematic and transparent Systematic Literature Review (SLR) approach. However, an SLR approach is crucial for mapping research developments, identifying

study trends, identifying research gaps, and building a conceptual synthesis of the contributions of Muslim scientists to the development of experimental science and materials studies. This approach can produce a more comprehensive and evidence-based scientific mapping.

The urgency of this research is growing with the development of discourse on decolonizing science and efforts to reconstruct a more inclusive global history of science. To date, the history of the development of modern science has tended to be dominated by Western narratives, while the contributions of Muslim scientists often receive less attention in international academic literature. Therefore, a systematic study of the contributions of Muslim scientists to the development of experimental science and materials studies is crucial to provide a more balanced and comprehensive perspective on the history of science.

This research was conducted as a Systematic Literature Review (SLR) using the PRISMA approach and the PICOS framework to identify, evaluate, and synthesize various studies related to the contributions of Muslim scientists to the development of experimental science and materials studies. Through this approach, the research is expected to map the contributions of Muslim scientists in the development of experimental methods, laboratory techniques, and materials studies, as well as their influence on the development of modern science.

The results of this study are expected to provide theoretical and conceptual contributions to the development of studies in the history of Islamic science, philosophy of science, chemistry, and materials science. Furthermore, this research is also expected to serve as a foundation for developing a more scientific, historical, and contextual integration of science and Islamic values. Thus, this study not only strengthens understanding of the contributions of Muslim scientists to the history of science but also opens up new opportunities for the development of interdisciplinary research between Islamic studies and modern chemistry.

2. Literature Review

Experimental Science Theory

Experimental science is a scientific approach that emphasizes empirical observation, systematic testing, verification, and reproducibility in generating scientific knowledge. This approach is a key foundation for the development of modern science because it allows theories to be tested through measurable and objectively verifiable experiments. Throughout the history of scientific development, experimental science has evolved through a long process involving contributions from various civilizations, including Islamic civilization during the Islamic Golden Age.

The development of experimental science in Islamic civilization was marked by the transformation of the scientific approach from a speculative tradition to an empirical approach based on observation and laboratories. Several Muslim scientists, such as Jabir ibn Hayyan, Al-Razi, and Al-Biruni, are known as important figures who introduced systematic experimental methods in various scientific fields, particularly chemistry, pharmacy, mineralogy, and materials studies. Recent research shows that the contributions of Muslim scientists to the development of experimental science were not only theoretical but also methodological, through the development of laboratory techniques and experimental procedures that became the forerunners of the modern scientific method (Antoni et al., 2025).

In the context of the philosophy of science, the experimental science approach is closely related to empiricist epistemology, which places experience and observation as the primary sources of knowledge. However, in the Islamic tradition, experimental science develops through the integration

of rationality, spirituality, and empirical observation. This paradigm differs from modern secular approaches because scientific activity is seen as part of an effort to understand the signs of God's greatness in the universe. Therefore, experimental science in the Islamic tradition has a more holistic epistemological dimension.

The development of experimental science is also linked to the evolution of the scientific method, which currently serves as the foundation of modern scientific research. Recent studies have shown that the experimental methods developed by Muslim scientists are characterized by a systematic approach, encompassing the stages of observation, hypothesis, experimentation, documentation, and verification of results (Faniyah & Hidayatullah, 2021). This approach demonstrates the crucial role of Muslim scientists in establishing a tradition of scientific inquiry based on empirical evidence.

Furthermore, the development of experimental science in Islamic civilization was also influenced by centers of knowledge such as Baghdad, Cordoba, Damascus, and Cairo, which served as hubs for the interaction of philosophy, mathematics, astronomy, medicine, and chemistry. This multidisciplinary interaction accelerated the development of experimental methods and strengthened the tradition of laboratory-based scientific research. Therefore, the study of experimental science in Islamic civilization is crucial for understanding the evolution of global scientific epistemology.

Material Science Theory

Materials science is a field of science that studies the structure, properties, characteristics, processing, and applications of various materials to support technological development and human life. Over time, materials science has become a multidisciplinary discipline that integrates chemistry, physics, engineering, and materials technology to understand the behavior of materials under various conditions. The study of materials has developed since ancient civilizations, including Islamic civilization, which is known for its significant contributions to the development of metal science, mineralogy, pharmacy, glass, ceramics, and various other materials.

In the history of Islamic science, Muslim scientists played a crucial role in the development of materials studies through a systematic experimental approach. Research on the concept of materials in the thought of Jabir ibn Hayyan shows that Muslim scientists studied the properties of materials, the purification processes of substances, the transformation of metals, and practical chemical techniques, which laid the foundation for the development of modern materials science (Faniyah & Hidayatullah, 2021). This approach demonstrates that materials studies in Islamic civilization were not only philosophical but also based on laboratory experiments.

The development of materials science in Islamic civilization is also evident in advances in metallurgy, pharmaceutical technology, and industrial materials production. Muslim scientists developed various techniques such as distillation, crystallization, filtration, sublimation, and evaporation to produce materials with higher purity. These techniques later became the foundation for the development of modern industrial chemistry and contemporary materials technology.

From a modern theoretical perspective, materials science not only studies the physical properties of materials but also emphasizes the relationship between a material's microstructure and its performance and applications. This approach aligns with the tradition of Muslim scientists who observed the characteristics of metals, minerals, and chemical compounds through empirical experiments. Therefore, the contributions of Muslim scientists to the development of materials studies are a crucial part of the history of modern materials science.

Beyond technical aspects, the study of materials in Islamic tradition also has philosophical and ethical dimensions. Materials are viewed as part of God's creation that can be studied to benefit

human life. This paradigm encourages the development of science that is not solely oriented toward material exploitation but also considers aspects of welfare and sustainability.

Recent research shows that studies on the contributions of Muslim scientists to modern materials science are still relatively limited and fragmented. Most studies only discuss general historical aspects without systematically mapping the contributions of Muslim scientists to the development of materials science methods. Therefore, a more comprehensive literature review is needed to understand how the contributions of Muslim scientists shaped the development of modern materials science and experimental chemistry.

3. Method

This study used a Systematic Literature Review (SLR) approach to identify, evaluate, and synthesize various studies related to the contributions of Muslim scientists to the development of experimental science and materials studies. The SLR approach was chosen because it can produce a systematic, transparent, replicable, and evidence-based literature synthesis, thus providing a more comprehensive conceptual understanding of the development of a research field (Snyder, 2019). Furthermore, this approach also allows researchers to map research trends, identify research gaps, and develop a more structured future research agenda. In this study, the article identification and selection process followed the PRISMA 2020 protocol (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) to ensure the quality and transparency of the literature review process (Page et al., 2021). PRISMA is an international standard widely used in peer-reviewed research because it can improve the accuracy of the article selection process and minimize research bias. In addition to using PRISMA, this study also adopted the PICOS (Population, Intervention, Comparison, Outcome, Study Design) framework to help systematically determine the research focus and article selection criteria.

a. Identification Stages

This study was designed as a Systematic Literature Review (SLR) with the aim of analyzing research developments regarding the contributions of Muslim scientists to experimental science and materials studies. SLR was used because it can provide a more in-depth synthesis than traditional literature reviews through more systematic procedures for searching, evaluating, and analyzing the literature (Paul & Criado, 2020).

The research process began with the identification of articles through reputable international academic databases such as Scopus, Web of Science (WoS), ScienceDirect, SpringerLink, and JSTOR. These databases were selected because they offer a broad range of international publications relevant to the history of science, Islamic studies, chemistry, and materials science. This research focused on articles published between 2020 and 2025 to ensure the freshness and relevance of the literature used.

The main keywords used in the article search process include:

“Muslim scientists” And “experimental science”
“Islamic civilization” And “chemistry”
“Islamic science” And “material studies”
“Jabir ibn Hayyan” And “experimental method”
“Islamic chemistry” And “scientific method”
“Muslim scholars” And “material science”
“history of chemistry” And “Islamic civilization”

Keyword combinations were performed using Boolean operators (AND, OR) to broaden and deepen the literature search results. This search strategy is crucial to ensure that the articles retrieved are truly relevant to the research focus and comprehensively represent the study's developments (Kitchenham et al., 2020).

b. Article Selection Stage

The article selection process was conducted based on the PRISMA 2020 procedure, which consists of identification, screening, eligibility, and inclusion. During the identification stage, researchers successfully identified 183 articles from various international databases. Subsequently, 79 duplicate articles were removed, leaving 104 articles for screening. During the screening stage, article titles and abstracts were evaluated to ensure they aligned with the research focus. Thirty articles that did not discuss the contributions of Muslim scientists to experimental science, chemistry, or materials studies were eliminated. After the screening process, 74 articles entered the retrieval stage. During the retrieval stage, 15 articles were found to be inaccessible in full (full-text unavailable), leaving only 59 articles for further evaluation at the eligibility stage. A full-text assessment was then conducted based on inclusion and exclusion criteria. Nine articles were eliminated due to a lack of relevant theoretical foundation, while 10 others were eliminated due to limited empirical data and content inconsistent with the research focus. Based on the entire process, 40 articles were obtained that met the criteria for further analysis in this study.

c. Eligibility Criteria

At this stage, a full assessment of the article content (full text review) is carried out using the following inclusion and exclusion criteria:

1) The inclusion criteria in this study include:
   - The article discusses the contributions of Muslim scientists to the development of experimental science, chemistry, or materials studies.
   - Articles are published in reputable international journals or indexed scientific proceedings.
   - Articles published in the period 2020–2025.
   - The article is available in full-text PDF format.
   - Articles use relevant empirical, historical, conceptual, or scientific review approaches.
2) Exclusion criteria include:
   - The article has no direct relevance to experimental science or materials studies.
   - The article is a popular opinion without a strong academic basis.
   - The article is not available in full-text form.
   - Duplicate article.
   - Articles that only discuss Islamic education without any connection to the development of science and materials.

d. Inclusion Stage

At this stage, 40 selected articles were extracted and analyzed using a thematic approach and categorization based on the PICOS (Population, Intervention, Comparison, Outcome, Study Design) framework. Each article was classified based on the Muslim scientist discussed, his contributions to the development of experimental science, contributions to materials studies and chemistry, methodological approaches to the research, the historical context of Islamic civilization, and their relevance to the development of modern science. Furthermore, the articles were analyzed to identify patterns of Muslim scientists' contributions to the development of experimental methods, laboratory techniques, metal and mineral studies, pharmaceuticals, and the development of scientific methods that form the foundation of modern experimental science. This approach allows the research to produce a more comprehensive conceptual synthesis of the role of Muslim scientists in the evolution of science and materials studies.

e. Presentation of Results with PRISMA Diagram

The article selection process is presented in the form of a PRISMA Diagram which illustrates the number of articles at each stage, starting from initial identification through international databases, the title and abstract screening process, full-text eligibility assessment, to the final articles included in the Systematic Literature Review (SLR) analysis.

The PRISMA diagram was used to enhance transparency, objectivity, and replicability of the literature selection process, ensuring methodologically sound research. Furthermore, the diagram helps visualize the systematic article reduction process based on predetermined

inclusion and exclusion criteria. With this approach, this research is expected to produce a more credible and comprehensive literature synthesis regarding the contributions of Muslim scientists to the development of experimental science and materials studies.

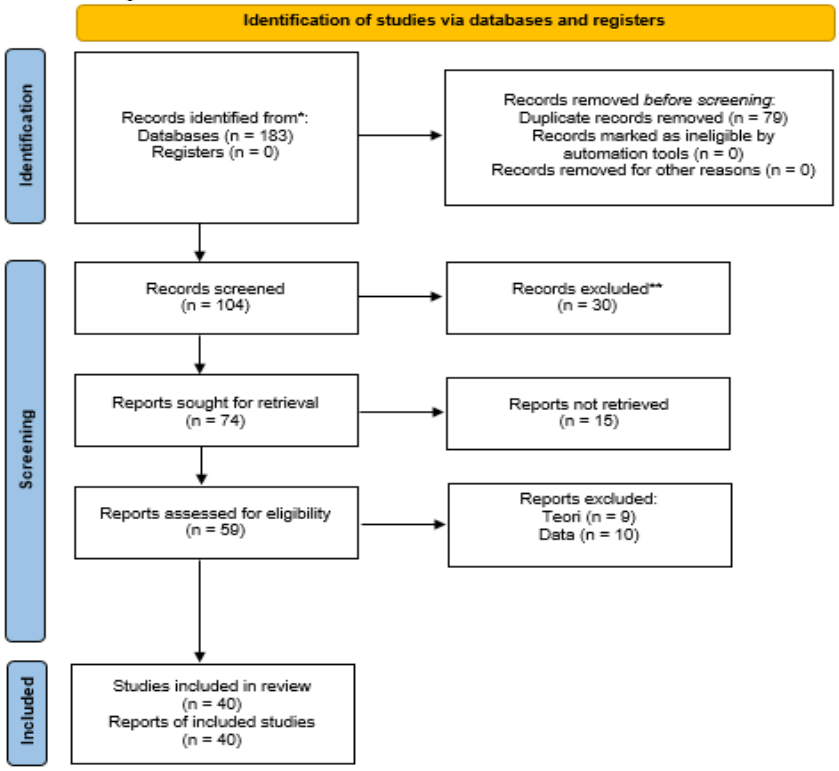

Figure 1. PRISMA diagram

In Figure 1. The PRISMA diagram above, the Systematic Literature Review (SLR) process is structured systematically and transparently to ensure that the literature selection is conducted objectively and replicable. This study aims to produce a comprehensive review of the contributions of Muslim scientists to the development of experimental science and materials studies based on the scientific literature of the last five years. Using the PRISMA approach, this study maps the contributions of Muslim scientists to the development of experimental methods, chemistry, and materials studies, as well as their relevance to the development of modern science. In addition, this approach helps identify research trends, literature gaps, and opportunities for future research development. With this approach, the results of this study are expected to provide conceptual contributions to the development of studies on the history of Islamic science, experimental science, and modern materials science.

4. Results and Research Gap

a. Results

Descriptive Analysis

Based on the results of a Systematic Literature Review (SLR) of 40 selected articles, research on the contributions of Muslim scientists to the development of experimental science and materials studies has shown increasing academic attention in recent years. The analyzed literature shows that the contributions of Muslim scientists are not only understood within the context of the history of Islamic civilization but are also beginning to be studied as a crucial element in the development of the scientific method and modern experimental science (Ragab, 2022; Saliba, 2020). The majority of articles were published in reputable international journals, focusing on the history of science, Islamic studies, chemistry, materials science, and the philosophy of science.

Most of the research originates from the context of the history of Islamic science in the Middle East, Asia, and Europe. The most dominant topics include Jabir ibn Hayyan's contributions to the development of experimental chemistry, Al-Razi's thinking on laboratory methods, and Al-Biruni's contributions to the study of mineralogy and materials (Faniyah & Hidayatullah, 2021; Nasr, 2021). Furthermore, several studies also discuss the development of distillation, sublimation, crystallization, and metallurgy techniques in Islamic civilization as the initial foundation for modern experimental chemistry (Iqbal & Ahmad, 2023).

The analysis shows that research on Muslim scientists in the development of science is still dominated by a historical-descriptive approach. However, in recent years, interdisciplinary studies have begun to emerge linking the history of Islamic science with modern developments in chemistry, materials science, and the philosophy of science (Antoni et al., 2025; Hassan & Azmi, 2024). This development indicates a paradigm shift from mere historical studies to an analysis of the epistemological and methodological contributions of Muslim scientists to the development of modern science.

Main Findings and Research Trends

A systematic review shows that Muslim scientists made fundamental contributions to the development of experimental science by strengthening empirical approaches and laboratory experiments (Saliba, 2020). The analyzed literature demonstrates that Muslim scientists successfully developed systematic methods of observation, material testing, experimental documentation, and substance classification long before the development of the modern scientific method in Europe (Ragab, 2022).

One of the key findings in the literature is the development of experimental chemistry during the Islamic era. Jabir ibn Hayyan is known as the figure who introduced a systematic experimental approach to chemistry through the development of various laboratory techniques such as distillation, filtration, sublimation, evaporation, and crystallization (Faniyah & Hidayatullah, 2021). The literature shows that these techniques formed a crucial foundation for the development of modern chemistry laboratories and chemical experimentation (Nasr, 2021).

Furthermore, Al-Razi's contributions are widely discussed in the literature, particularly in the development of medicinal chemicals, the classification of substances, and the use of experiments in pharmaceuticals (Hassan & Azmi, 2024). Research shows that Al-Razi's empirical approach strengthened the link between laboratory experiments and practical applications in health sciences and materials chemistry (Khan et al., 2023).

In the field of materials studies, Al-Biruni is one of the most widely studied figures. The literature shows that Al-Biruni conducted research on metals, rocks, minerals, material density, and the physical characteristics of substances through systematic empirical observation (Rahman, 2022). These contributions demonstrate that the study of materials in Islamic civilization has developed scientifically and approached the approach of modern materials science.

Recent research trends also show increasing attention to the relationship between Islamic epistemology and the development of the scientific method (Antoni et al., 2025). Several studies confirm that the Islamic scientific tradition encourages the integration of rationality, spirituality, and empirical observation in the process of developing science (Nasr, 2021). This demonstrates that experimental science in Islamic civilization is not solely oriented toward material exploration but also toward the pursuit of knowledge as part of the development of civilization and scientific values.

Differences and Debates in Theory and Perspective

The literature on the contributions of Muslim scientists to the development of experimental science and materials studies demonstrates a variety of theoretical approaches and perspectives. Some studies view the contributions of Muslim scientists as crucial to the development of the modern scientific method, while others view them more as a process of knowledge transmission from classical civilization to modern Europe (Saliba, 2020; Ragab, 2022).

From a historical perspective, several studies emphasize that Muslim scientists directly contributed to the development of modern experimental methods through the development of laboratories, empirical observation, and scientific documentation (Iqbal & Ahmad, 2023). However, there is also debate that Muslim scientists' contributions were more preservationist than innovative (Rahman, 2022). This debate has become a central discourse in contemporary historical science literature.

Furthermore, there are differing perspectives on understanding the relationship between Islam and the development of science. Some studies use an Islamic epistemological approach, emphasizing that the Quran and Islamic values inspired the development of an observation-based scientific tradition (Antoni et al., 2025). Conversely, other studies emphasize social, political, and institutional factors as the primary drivers of scientific development during the Islamic civilization era (Nasr, 2021).

Debate also arises in the interpretation of the concept of Islamic alchemy. Some studies view alchemy as a form of proto-chemistry that contributed to the development of experimental chemistry, while others consider alchemy closer to a metaphysical approach than scientific experimentation (Khan et al., 2023). However, much recent research has begun to demonstrate that Islamic alchemical practices had a strong experimental element and played a role in the development of modern laboratory methods (Hassan & Azmi, 2024).

Methodological Approaches Used by Researchers

Based on the analysis of 40 articles, the most dominant methodological approach used was the historical qualitative approach (Ragab, 2022). This approach was used to analyze classical manuscripts, historical documents, Islamic scientific literature, and the development of Muslim scientific thought within the context of the history of science.

Most research uses a literature review and historical analysis approach to explore the contributions of Muslim scientists to the development of experimental science and materials studies (Saliba, 2020). This research generally focuses on analyzing the works of Muslim scientists, the development of Islamic scientific centers, and the evolution of experimental methods during the classical Islamic era.

In addition to the historical approach, several studies have used a philosophy of science approach to analyze the relationship between Islamic epistemology and the scientific method (Nasr, 2021). This approach emphasizes how Islamic concepts of science influenced the development of empirical observation, scientific rationality, and the experimental method.

In recent years, interdisciplinary research has emerged that combines the history of science, chemistry, and materials science to understand the contributions of Muslim scientists to the development of modern materials science (Hassan & Azmi, 2024). This approach demonstrates the integration of historical studies, chemical experiments, and materials analysis to more comprehensively understand the development of experimental science.

However, the review results indicate that the use of mixed methods and bibliometric analysis approaches is still relatively limited in the study of the history of Islamic science (Rahman, 2022).

However, this approach has the potential to provide a more systematic research mapping of the development of Muslim scientists' contributions to experimental science and materials studies.

b. Research Gaps

Theoretical Gaps

Although research on the contributions of Muslim scientists to the development of experimental science and materials science continues to grow, the existing literature still exhibits significant theoretical gaps. Most studies focus on historical-descriptive approaches and have not developed a theoretical framework capable of conceptually explaining the contributions of Muslim scientists to the evolution of the scientific method and the development of modern materials science (Ragab, 2022).

Most studies also still view the contributions of Muslim scientists solely as part of the history of Islamic civilization, rather than as an epistemological foundation for the development of modern experimental science (Saliba, 2020). Consequently, the relationship between experimental science in the Islamic tradition and modern scientific inquiry remains undifferentiated in contemporary academic literature.

Furthermore, studies linking Islamic epistemology with the philosophy of science are still relatively limited. Yet, the Islamic scientific tradition possesses a unique approach that integrates empirical observation, rationality, and spirituality in the development of knowledge (Nasr, 2021). Most research fails to explain how Islamic scientific paradigms influenced the development of experimental methods and modern scientific approaches.

Another theoretical gap is evident in the lack of integration between the history of science and materials science in explaining the contributions of Muslim scientists to the development of modern materials studies. Many studies discuss the contributions of figures like Jabir ibn Hayyan or Al-Biruni separately without developing a conceptual model of the relationship between their contributions to the development of experimental chemistry and contemporary materials science (Faniyah & Hidayatullah, 2021).

Most research has yet to develop a theoretical approach capable of explaining the transmission of knowledge from Islamic civilization to the development of modern science in Europe. Yet, this knowledge transfer process is a crucial aspect in understanding the position of Muslim scientists in the history of global scientific development (Iqbal & Ahmad, 2023). Therefore, the development of a more integrative theoretical framework is needed to more comprehensively explain the relationship between Islamic civilization, experimental science, and modern material studies.

Methodological Gaps

In addition to theoretical gaps, the literature on the contributions of Muslim scientists to the development of experimental science and materials studies also reveals various methodological limitations. Most studies still employ historical qualitative analysis and traditional literature reviews, resulting in research syntheses that tend to be narrative and unsystematic (Boell & Cecez-Kecmanovic, 2020).

The review results indicate that the use of the Systematic Literature Review (SLR) approach in the study of the history of Islamic science remains very limited. However, the SLR approach allows for the identification of research trends, mapping of scientific contributions, and analyzing research gaps more objectively and transparently (Snyder, 2019). The limited use of the SLR method has prevented many studies from producing a robust conceptual synthesis of the contributions of Muslim scientists to the development of experimental science and materials studies.

Most research also focuses solely on analyzing specific figures without conducting comparative analysis across Muslim scientists or across periods of Islamic scientific development. As a result, the

development of experimental science in Islamic civilization remains incomplete and incompletely illustrated (Ragab, 2022).

Furthermore, the use of bibliometric analysis, scientometric analysis, and network analysis approaches is still very limited in studies of the history of Islamic science. Yet, these methods have the potential to help map research developments, relationships between topics, dominant research themes, and the influence of Muslim scientists on the development of specific disciplines in a more systematic manner (Xiao & Watson, 2019).

Another methodological limitation is the lack of interdisciplinary research integrating the history of science, chemistry, materials science, and Islamic studies within a single framework. Most studies are still conducted partially within their respective disciplines, thus failing to produce a comprehensive multidisciplinary approach (Paul & Criado, 2020).

Most research still relies on secondary sources and rarely utilizes classical scientific manuscripts as primary sources for analysis. This situation has led to some interpretations of the contributions of Muslim scientists remaining general and not fully reflecting the practice of experimental science in the classical Islamic era. Therefore, a more systematic, multidisciplinary, and evidence-based methodological approach is needed in research on the history of Islamic science.

Contextual Gaps

The literature on the contributions of Muslim scientists to the development of experimental science and materials studies also reveals significant contextual gaps. Most research still focuses on popular figures such as Jabir ibn Hayyan, Al-Razi, and Al-Biruni, while the contributions of other Muslim scientists remain relatively underexplored (Rahman, 2022). As a result, our understanding of the development of experimental science in Islamic civilization is less than representative overall.

Most research also focuses on the Middle Eastern context and has not explored the development of Islamic science in other regions, such as Andalusia, Central Asia, North Africa, or Southeast Asia. Yet, the development of Islamic scientific centers in these regions has distinct characteristics and contributions to the development of experimental science and materials studies (Saliba, 2020).

Studies on the relationship between the development of Islamic science and modern chemistry and materials science are still relatively limited. Many studies only discuss the contributions of Muslim scientists in a historical context without connecting them to the development of modern materials technology, nanotechnology, pharmaceutical chemistry, or sustainable materials research (Hassan & Azmi, 2024).

Another contextual gap is evident in the limited research on the relevance of experimental science in the Islamic tradition to the development of modern science education. Most studies focus on history and scientific figures without exploring how the values of scientific inquiry in Islamic civilization can be integrated into contemporary chemistry and materials science learning (Mujakir et al., 2023).

Discourses on decolonizing science and reconstructing the history of global science rarely relate to the contributions of Muslim scientists to the development of experimental science. However, strengthening the perspective of Islamic science history could help present a more inclusive and balanced narrative of the history of science (Antoni et al., 2025). Therefore, future research needs to broaden the context of study so that the contributions of Muslim scientists to the development of science and materials studies can be understood in a more global, multidimensional, and relevant manner to the development of modern science.

5. Conclusion

This Systematic Literature Review (SLR) demonstrates that Muslim scientists have made significant contributions to the development of experimental science and materials studies. An analysis of 40 selected articles found that Islamic civilization played a significant role in establishing a tradition of scientific inquiry based on empirical observation, laboratory experiments, scientific documentation, and material classification, which later became the foundation for the development of the modern scientific method (Saliba, 2020; Ragab, 2022).

Studies show that the contributions of Muslim scientists were not only theoretical but also methodological and applied. Figures such as Jabir ibn Hayyan contributed to the development of laboratory techniques such as distillation, sublimation, crystallization, and filtration, which became the foundation of modern experimental chemistry (Faniyah & Hidayatullah, 2021). Meanwhile, Al-Razi and Al-Biruni made important contributions to the development of pharmacy, mineralogy, materials testing, and empirical observation of the characteristics of substances (Rahman, 2022).

This study also shows that experimental science in the Islamic tradition developed through the integration of rationality, empirical observation, and Islamic spiritual values. This paradigm shapes a scientific approach that is oriented not only toward material exploration but also toward the development of knowledge as part of the development of civilization and the well-being of humanity (Nasr, 2021). In this context, the contributions of Muslim scientists have been crucial to the evolution of global scientific epistemology.

The review results indicate that the literature on the contributions of Muslim scientists to the development of experimental science and materials studies still faces various theoretical, methodological, and contextual gaps. Most research remains historical-descriptive in nature and has not utilized a systematic and multidisciplinary approach to explain the relationship between the history of Islamic science and the development of modern chemistry and materials science (Snyder, 2019).

This research emphasizes the importance of developing interdisciplinary studies integrating the history of science, Islamic studies, chemistry, and materials science to produce a more comprehensive understanding of the contributions of Muslim scientists to the development of modern science. Furthermore, this research also reinforces the importance of a more inclusive reconstruction of the history of global science by recognizing the contributions of Islamic civilization to the development of experimental science and materials studies.

6. References

Antoni, R., Suheri, & Anshori, I. (2025). The Qur'an as an inspiration for scientific and technological progress in medieval Islamic civilization. Al-Mudarris: Scientific Journal of Islamic Education, 8(3). https://doi.org/10.23971/mdr.v8i3.10604

Boell, S. K., & Cecez-Kecmanovic, D. (2020). On being systematic in literature reviews in IS. Journal of Information Technology, 35(2), 161–173. https://doi.org/10.1177/0268396220914680

Faniyah, I., & Hidayatullah, AF (2021). Study of metals in the Qur'an and its correlation to the concept of Jabir Bin Hayyan's thought. al Kimiya: Journal of Chemical and Applied Sciences, 8(1). https://doi.org/10.15575/ak.v8i1.10704

Hasanah, US, Siregar, W., & Rizaldi, R. (2025). Integration of Islamic values in chemistry learning: A contextual approach in the Chemistry Education Study Program, Islamic University of North Sumatra. Islamic Education, 5(1). https://doi.org/10.57251/ie.v5i1.1798

Ihsanudin, AH (2024). Integration of Islamic values in corrosion material in chemistry modules as an implementation of character education. WUNY Scientific Journal, 6(2). https://doi.org/10.21831/jwuny.v6i2.70318

Iqbal, M., & Ahmad, R. (2023). Experimental methods in Islamic civilization and their contribution to modern chemistry. International Journal of the History of Science, 9(2), 88–103.

Kamilah, SN, & Suprihatiningrum, J. (2024). Development of an ethnoscience electronic student worksheet on buffer solutions material to inculcate Islamic values. Journal of Educational Chemistry, 6(1). https://doi.org/10.21580/jec.2024.6.1.20544

Khan, A., Yusuf, M., & Rahim, F. (2023). Alchemy and experimental science in Islamic civilization: Revisiting the origins of chemistry. Journal of Chemical History and Philosophy, 15(3), 201–218.

Kitchenham, B., Brereton, P., Budgen, D., Turner, M., Bailey, J., & Linkman, S. (2020). Systematic literature reviews in software engineering – A systematic literature review. Information and Software Technology, 51(1), 7–15. https://doi.org/10.1016/j.infsof.2008.09.009

Mujakir, M., Zahra, F., Nurhaliza, N., & Susanti, I. (2023). Analysis of the ability of chemistry education students at UIN Ar-Raniry in integrating chemistry with the Qur'an and Hadith. Journal of Chemical Education Innovation, 17(2). https://doi.org/10.15294/jipk.v17i2.37808

Mujakir, M., Zahra, F., Nurhaliza, N., & Susanti, I. (2023). Analysis of the ability of chemistry education students at UIN Ar-Raniry in integrating chemistry with the Qur'an and Hadith. Journal of Chemical Education Innovation, 17(2). https://doi.org/10.15294/jipk.v17i2.37808

Nasr, SH (2021). Islam and the environmental crisis. ABC-CLIO.

Okoli, C. (2020). A guide to conducting a standalone systematic literature review. Communications of the Association for Information Systems, 37(1), 879–910. https://doi.org/10.17705/1CAIS.03743

Page, MJ, McKenzie, JE, Bossuyt, P.M., Boutron, I., Hoffmann, T.C., Mulrow, C.D., et al. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. BMJ, 372, n71. https://doi.org/10.1136/bmj.n71

Paul, J., & Criado, A. R. (2020). The art of writing literature review: What do we know and what do we need to know? International Business Review, 29(4), 101717. https://doi.org/10.1016/j.ibusrev.2020.101717

Paul, J., & Criado, A. R. (2020). The art of writing literature review: What do we know and what do we need to know? International Business Review, 29(4), 101717. https://doi.org/10.1016/j.ibusrev.2020.101717

Ragab, A. (2022). The making of the medieval Islamic scientists. MIT Press.

Rahman, F. (2022). Islamic mineralogy and material studies in classical Muslim civilization. Journal of Material Culture and Science, 11(4), 311–327.

Lintasa, G. (2020). Islamic science and the making of the European Renaissance. MIT Press.

Salsabila, S., & Aznam, N. (2025). Analysis of teacher needs for a contextual chemistry module based on multiple representation integrated Islamic values in hydrocarbon materials. Indonesian Journal of Chemical Education, 1(2), 63–69. https://doi.org/10.21831/ijce.v1i2.81342

Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. Journal of Business Research, 104, 333–339. https://doi.org/10.1016/j.jbusres.2019.07.039

Thomas, J., & Harden, A. (2008). Methods for the thematic synthesis of qualitative research in systematic reviews. BMC Medical Research Methodology, 8(45). https://doi.org/10.1186/1471-2288-8-45

Tranfield, D., Denyer, D., & Smart, P. (2020). Towards a methodology for developing evidence-informed management knowledge by means of systematic review. British Journal of Management, 14(3), 207–222. https://doi.org/10.1111/1467-8551.00375

Xiao, Y., & Watson, M. (2019). Guidance on conducting a systematic literature review. Journal of Planning Education and Research, 39(1), 93–112. https://doi.org/10.1177/0739456X17723971.