



Legacy of Muslim Scholars in Advancing Arithmetic and Geometry During the Islamic Golden Age: Modern Lessons for Stem Education

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Abstract

The legacy of Muslim scholars in advancing arithmetic and geometry during the Islamic Golden Age (8th–14th century) reflects one of history’s greatest periods of scientific and intellectual achievement. This era not only safeguarded ancient mathematical knowledge but also produced transformative innovations, particularly through the works of Al-Khwarizmi, Thabit ibn Qurra, and Ibn al-Banna. Al-Khwarizmi formalized the Hindu-Arabic numeral system and established foundational principles of algebra and algorithmic computation, shaping European mathematics for centuries. Thabit ibn Qurra extended the Pythagorean theorem and made significant contributions to geometry and number theory, while Ibn al-Banna advanced arithmetic methods used in commerce, astronomy, and education. These achievements flourished within a vibrant scholarly ecosystem, from Baghdad’s House of Wisdom to the intellectual hubs of Al-Andalus and Sicily. Through the translation movement, Greek, Indian, and Persian works were not only preserved but critically examined, corrected, and expanded. This process directly influenced European figures such as Fibonacci and played a pivotal role in laying the groundwork for the Renaissance. Muslim mathematicians were far more than transmitters—they were innovators whose legacy underscores the global nature of mathematical progress. Integrating these contributions into STEM education can foster cultural inclusivity, historical accuracy, and higher-order thinking skills. Their emphasis on practical application, theoretical rigor, and interdisciplinary inquiry offers valuable lessons for modern pedagogy. To maximize this potential, educational reforms should include curriculum updates, teacher training, and digital preservation of classical texts, alongside renewed research into lesser-known scholars, ensuring their enduring relevance in contemporary classrooms.

Keywords: Islamic Mathematics; Arithmetic; Geometry; Islamic Golden Age; STEM education

Introduction

The legacy of Muslim scholars in the development of arithmetic and geometry during the Islamic Golden Age is best understood within the broader historical context of intellectual exchange and scholarly advancement between the 8th and 14th centuries. Far from merely preserving ancient knowledge, Islamic civilisation significantly expanded and disseminated mathematical concepts through a vibrant culture of critical inquiry and innovation. Working in esteemed centres of learning such as Bayt al-Ḥikmah (the House of Wisdom) in Baghdad, Muslim mathematicians engaged rigorously with the classical works of Greek, Indian, and Persian origin, not only translating them but also correcting inaccuracies, formulating new theorems, and pioneering original methodologies (Gutas, 2018; Saliba, 2022).

Mathematics during this period was deeply integrated with religious, scientific, and practical life. The precise calculation of inheritance shares, the determination of qiblah (direction of prayer), and the design of architectural marvels all relied heavily on mathematical precision (Dhanani, 2020; Nasr, 2021). In arithmetic, the assimilation and enhancement of the Hindu-Arabic numeral system, particularly the introduction and widespread use of zero, revolutionised computation and greatly advanced commerce, astronomy, and science (Berggren, 2021). Prominent figures such as al-Khwārizmī laid the foundational principles of algebra and algorithmic thinking, while Thābit ibn Qurra made notable strides in geometry and number theory. Equally significant was Ibn al-Haytham, whose analytical approach to geometry and optics anticipated several concepts of algebraic geometry and the scientific method (Al-Khalili, 2019; Ahmed, 2021). These scholars exemplified a methodical and original approach to knowledge, producing treatises that were later translated into Latin and became pivotal to the European scientific renaissance. The influence of Islamic mathematics on European scholars such as Fibonacci attests to its enduring and global legacy (Saliba, 2022).

By re-evaluating these achievements, contemporary mathematics education can benefit not only from their technical insights but also from a culturally inclusive narrative. Integrating these contributions into STEM curricula fosters a more comprehensive understanding of global scientific heritage and highlights mathematics as a universal tool for human advancement through cross-cultural collaboration and innovation (Ahmed, 2021; Dhanani, 2020; Nasr, 2021).

This paper therefore revisits the historical contributions of Muslim scholars to arithmetic and geometry, with a focus on their original works, practical applications, and long-term impact on global

mathematics. It also considers the relevance of these contributions to modern educational contexts, advocating for their inclusion in efforts to decolonise and diversify mathematical knowledge.

The Golden Age of Islamic Civilisation and Knowledge Transmission

The period spanning the 8th to 14th centuries CE is commonly referred to as the Golden Age of Islamic civilisation, a time marked by unprecedented advancements in science, mathematics, medicine, philosophy, and literature. Central to this flourishing of intellectual activity was the deliberate and strategic cultivation of knowledge by various caliphs, most notably the Abbasid rulers. Under their patronage, a profound engagement with scholarly traditions of the past—Greek, Indian, Persian, and Babylonian—took place, leading to a unique synthesis that shaped the development of global science and mathematics (Gutas, 2018; Nasr, 2021).

One of the most significant institutions of this era was the *Bayt al-Ḥikmah* (House of Wisdom), established in Baghdad by Caliph al-Ma'mūn in the early 9th century. This intellectual centre functioned as a library, translation bureau, and academy, drawing together scholars of diverse backgrounds and religious affiliations—including Muslims, Christians, Jews, and Zoroastrians (Saliba, 2022). Through collaborative scholarship, they translated key works of Greek mathematicians such as Euclid, Archimedes, and Ptolemy into Arabic, often providing critical commentaries, corrections, and extensions to the original texts (Berggren, 2021). Muslim scholars were not passive recipients of earlier knowledge but active contributors who adapted and expanded on what they encountered. For instance, the translation of Indian numeral systems laid the foundation for the introduction of what is now referred to as the Hindu-Arabic numeral system, which replaced the cumbersome Roman numerals in Europe centuries later (Al-Khalili, 2019). This numerical innovation, championed by scholars like al-Khwārizmī, revolutionised arithmetic by enabling place-value calculation and the concept of zero—both crucial for the development of algebra and modern computation (Dhanani, 2020).

Moreover, the transmission of knowledge was not confined to Baghdad alone. Centres of learning such as Cordoba, Toledo, Cairo, and Samarqand became vibrant hubs where scholarly exchange flourished. In Al-Andalus (Muslim Spain), for instance, institutions like the *Madrasah of Cordoba* and the libraries of Toledo served as vital conduits through which Arabic mathematical works were translated into Latin and Hebrew, eventually influencing European thought during the Renaissance (Ahmed, 2021). This period also witnessed the compilation of extensive treatises and encyclopaedias

that not only documented mathematical theories but also explored their practical applications in fields such as astronomy, engineering, commerce, and architecture. Knowledge transmission thus operated on both horizontal (across regions and disciplines) and vertical (across generations) dimensions, ensuring the longevity and adaptability of Islamic contributions to mathematics.

In essence, the Golden Age of Islamic civilisation laid the intellectual infrastructure upon which later mathematical developments in Europe and the wider world were constructed. It created a dynamic and inclusive environment where translation was not merely linguistic but also cultural and epistemological, blending diverse traditions into a cohesive and productive body of knowledge.

Muslim Scholars' Contributions to Arithmetic

A. Al-Khwārizmī and the Decimal System

One of the most influential figures in the history of arithmetic is Muḥammad ibn Mūsā al-Khwārizmī, a 9th-century Persian scholar whose work laid the foundations for modern number theory and computational methods. Often referred to as the “father of algebra,” al-Khwārizmī’s contributions extend significantly into the realm of arithmetic, particularly through his systematic introduction of the Hindu-Arabic numeral system and the development of early algorithmic thinking (O'Connor & Robertson, 2021).

In his renowned work, *Kitāb al-ḥisāb al-hindī* (The Book of Calculation with Hindu Numerals), al-Khwārizmī introduced a revolutionary method of numerical representation that incorporated place value and the use of zero—a concept largely absent in the Greek and Roman numerical traditions. This new system enabled simpler computation, making arithmetic operations such as addition, subtraction, multiplication, and division more efficient and accessible. The numerals he described are the ancestors of those used globally today: 0–9 (Hogendijk, 2022). Al-Khwārizmī’s work not only spread across the Islamic world but also played a crucial role in transforming European mathematics. Latin translations of his arithmetic texts, particularly during the 12th century, were instrumental in replacing the clumsy Roman numeral system with the more versatile decimal system in European education and commerce (Burnett, 2020). The term “algorithm” itself is derived from the Latinised form of his name, “Algoritmi,” illustrating his lasting legacy in the field of computation (Katz, 2022).

Moreover, al-Khwārizmī approached arithmetic not simply as a theoretical discipline but as a practical tool essential for solving everyday problems in trade, inheritance, and surveying. His

emphasis on clarity, step-by-step instructions, and real-life examples made his works pedagogically effective and enduring. His arithmetic treatises laid the foundation for systematic learning, influencing the structure of mathematics education in both the Islamic world and medieval Europe (Eisenstein, 2021).

In sum, al-Khwārizmī's role in the advancement of arithmetic cannot be overstated. His introduction of the Hindu-Arabic numerals, his formulation of algorithms, and his methodical approach to calculation helped transform mathematics from a purely scholarly endeavour into a universally applicable science. His legacy continues to shape the way arithmetic is taught and understood in classrooms around the world today.

B. Abū Kāmil and the Expansion of Computation

Following the foundational work of al-Khwārizmī, later Muslim mathematicians advanced arithmetic by expanding its conceptual boundaries and practical applications. One of the most prominent figures in this development was Abū Kāmil Shujā' ibn Aslam, often referred to as “the Egyptian calculator.” Active in the late 9th and early 10th centuries, Abū Kāmil was instrumental in extending arithmetic beyond the basic manipulation of whole numbers by systematically incorporating irrational numbers, ratios, and more complex numerical operations (Sesiano, 2021). Abū Kāmil's arithmetic prowess is most evident in his ability to handle roots and irrational quantities—concepts that were treated with suspicion or ambiguity by earlier mathematicians. He treated surds such as $\sqrt{2}$ and $\sqrt{5}$ not merely as approximations but as valid quantities that could be manipulated algebraically and arithmetically. This approach was revolutionary and marked a critical evolution in the understanding of number systems (Folkerts & Plofker, 2022). His competence in operating with these irrational numbers laid essential groundwork for the later development of algebraic theory and numerical analysis in both the Islamic and European mathematical traditions.

Furthermore, in his influential work, *Kitāb al-ḥisāb bi-l-muqābala wa-l-muwāzanah* (The Book of Calculation by Restoration and Balancing), Abū Kāmil elaborated on arithmetic operations involving fractions, powers, and roots, enabling a far broader range of problem-solving than had previously been possible. He often tackled problems involving area, volume, and inheritance using advanced arithmetical reasoning, demonstrating how arithmetic could address practical societal needs (Hogendijk, 2022).

Abū Kāmil's influence extended well beyond his own era. His works were extensively cited by later mathematicians, including Fibonacci, who directly used Abū Kāmil's methods in his seminal text *Liber Abaci* (1202). This transmission of knowledge from the Islamic world to Latin Europe illustrates Abū Kāmil's role as a bridge between civilisations, contributing significantly to the arithmetic education of the medieval West (Burnett, 2020).

In essence, Abū Kāmil's contributions expanded the scope of arithmetic from basic computation to a more abstract and powerful analytical tool. His treatment of irrational numbers, detailed problem-solving strategies, and systematic use of ratios elevated arithmetic to a new level of mathematical maturity. Today, his legacy endures in the way modern mathematics embraces and applies complex number systems in both theoretical and practical contexts.

C. Ibn al-Bannā and Practical Arithmetic

Among the later Muslim mathematicians who significantly contributed to applied arithmetic was Abū al-‘Abbās Aḥmad ibn Muḥammad ibn ‘Uthmān al-Azdī al-Marrākushī, commonly known as Ibn al-Bannā' al-Marrākushī (c. 1256–1321 CE). He was a Moroccan mathematician, astronomer, and jurist whose works epitomise the integration of theoretical mathematics with practical needs in everyday life, especially in areas such as commerce, inheritance distribution (*Ilm al-Farā'id*), and routine financial calculations (Lamrabet, 2021).

Ibn al-Bannā's most widely circulated work, *Talkhīṣ ‘amal al-ḥisāb* (Summary of Arithmetical Operations), served as a pedagogical handbook that taught not only the fundamentals of arithmetic but also how these principles could be applied to solve real-life problems. Unlike many earlier mathematical treatises that were abstract or geometric in nature, his writings focused on practical arithmetic, such as profit and loss, partnership, tax calculation, and land measurement (Omar, 2022). This made his works especially useful for merchants, judges (*qāḍīs*), and administrators. One of the most important fields where Ibn al-Bannā's arithmetic was applied was *Ilm al-Farā'id*, the Islamic law of inheritance. This area of jurisprudence requires precise fractional calculations based on Qur'anic injunctions. Ibn al-Bannā systematised the arithmetical methods needed to determine the shares of heirs in various family structures, thereby contributing to both religious scholarship and legal administration (Marrakchi, 2023).

Moreover, Ibn al-Bannā was among the earliest scholars to discuss arithmetical operations involving zero, negative numbers, and indeterminate problems—topics that show the growing sophistication of mathematical thinking in the Islamic world at that time (Djebbar, 2022). His attention to the needs of society ensured that mathematics remained relevant to the economic and legal systems of the Maghreb and beyond. Notably, Ibn al-Bannā's approach combined clarity, brevity, and real-world applicability, making his texts suitable for teaching purposes. His influence extended throughout North Africa and Andalusia, where his manuals continued to be used for centuries in Islamic courts and educational institutions (Chemla & Keller, 2023).

In summary, Ibn al-Bannā's practical arithmetic bridged the gap between abstract mathematical theory and the realities of daily life. His legacy lies not only in his scholarly depth but also in his enduring impact on Islamic legal thought, commerce, and education, demonstrating how mathematics could serve both divine law and human affairs.

Muslim Scholars' Contributions to Geometry

A. Thābit ibn Qurra's Geometrical Theorems

Among the most remarkable contributors to Islamic geometry during the Golden Age was Thābit ibn Qurra (c. 836–901 CE), a polymath from Harran who made significant advancements in mathematics, astronomy, and mechanics. His contributions to geometry, particularly in the generalisation of the Pythagorean theorem and the development of original geometrical proofs, marked a critical turning point in the evolution of mathematical thought (Rashed, 2020).

Thābit ibn Qurra extended the classic Pythagorean theorem—traditionally confined to right-angled triangles—by developing a broader version that applied to any triangle, not just those with a right angle. This generalisation involved the construction of specific segments within a triangle to demonstrate relationships between the squares of the sides and the projection of angles, laying the groundwork for later formulations of the Law of Cosines (Said, 2021). His approach showed not only mathematical creativity but also a deep understanding of spatial reasoning and abstract logic.

In addition to his original theorems, Thābit played a central role in the translation and critical analysis of Greek geometrical works, especially those of Euclid, Archimedes, and Apollonius. Working in Baghdad's House of Wisdom, he translated and revised key parts of *Euclid's Elements*, offering improved proofs and resolving ambiguities found in earlier translations (Gutas, 2019). His

contributions ensured that Greek geometry was not merely preserved but actively developed and integrated into the broader framework of Islamic mathematics.

Thābit's translations went beyond linguistic conversion—they were intellectual expansions. For example, in his commentary on *Elements*, he introduced alternative demonstrations for propositions using Arabic mathematical notation, providing a clearer and more accessible interpretation for scholars of his time. His work later influenced both Islamic and European mathematicians, including al-Tūsī and Fibonacci, by laying a foundation for synthetic geometry and more advanced trigonometric reasoning (Kennedy, 2023). What distinguishes Thābit ibn Qurra is his dual role as both a preserver of ancient knowledge and an innovator of new ideas. His geometric insights demonstrate how Islamic scholars did not merely inherit classical thought—they transformed it into something richer and more enduring. His legacy lives on in the way geometry is approached as a tool for logical deduction, visual learning, and scientific application.

B. Al-Tusi and the Development of Trigonometry

Nasir al-Din al-Tusi was a pioneering Persian mathematician whose seminal work established trigonometry as a distinct branch of mathematics, independent from its earlier ties to astronomy. In his influential "Treatise on the Quadrilateral," al-Tusi provided the first comprehensive exposition of both plane and spherical trigonometry. He systematically listed the six possible cases for a right-angled spherical triangle and introduced essential formulas, such as the sine law for plane triangles $\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$ the sine law for spherical triangles, and the law of tangents for spherical triangles. These rigorous treatments and proofs transformed trigonometry from a mathematical tool for astronomers into a standalone science, laying groundwork that would be built upon by European mathematicians centuries later (Al-Tusi, 13th century, as discussed in Wikipedia, 2003; University of St Andrews, 2018; Purwanti, 2017).

Spherical Geometry and Its Implications for Astronomy and Geography

Spherical geometry addresses the properties of figures on the surface of a sphere, which are fundamentally different from classical Euclidean geometry. For instance, in spherical triangles, the sum of the angles exceeds 180° , and the shortest path between two points is an arc of a great circle.

These principles were vital for the evolution of astronomy and geography. Spherical trigonometry allowed astronomers to accurately determine the positions of stars and planets on the celestial sphere, essential for the development of sophisticated star charts, navigation by sea, and the calculation of geographical coordinates on Earth (Spherical Astronomy, 2005; Non-Euclidean Geometry Class Notes, 2024). The practical applications extended to improvements in timekeeping, navigation (for instance, in defining latitude and longitude), and the mathematical underpinning of cartography (UiO, 2025).

Geometrical Art and Architecture

Islamic art is celebrated for its intricate use of geometric patterns, which adorn mosques, palaces, and countless decorative objects. These patterns rely on deep mathematical principles, primarily *geometry*, to create visually harmonious and complex motifs. Artists use simple tools—a compass and straightedge—to generate circles and lines, constructing grids of polygons such as triangles, squares, and hexagons. Through the principle of tessellation (repeating a single geometric unit to fill a plane without gaps), Islamic designers achieve an illusion of infinity, symbolising the infinite nature of Allah and the underlying order of the cosmos (Metropolitan Museum of Art, n.d.; Deen Arts Foundation, 2023).

Symmetry and Tessellation: Teaching Mathematical Aesthetics

Symmetry—both radial (rotational) and bilateral—forms the cornerstone of Islamic geometric design. Patterns often radiate from a central point, creating unity and harmony reflective of divine order. The use of tessellation—where polygons, most notably regular forms such as triangles and hexagons, are repeated seamlessly—teaches not just mathematical concepts but also a unique aesthetic that deeply influences students' perception of beauty in mathematics and art.

These artistic achievements have inspired Western artists, such as M.C. Escher, and continue to be a compelling way to link mathematical instruction with visual cultural heritage (Fiveable, 2024; Rashidi, 2023). In educational settings, exploring such patterns offers a powerful means of engaging students with abstract mathematical ideas through visual language, symmetry, repetition, and order.

Influence on European Mathematics

The influence of Muslim scholars on European mathematics is a significant chapter in the history of science, one that challenges the often-Eurocentric narrative of mathematical progress. From the 10th century onward, knowledge developed in the Islamic world began to flow into Europe, particularly through Al-Andalus (Muslim Spain) and Sicily, two regions where Islamic and European cultures met, interacted, and eventually merged intellectually (Burnett, 2021).

In Al-Andalus, cities such as Toledo, Seville, and Cordoba became major centres of translation and intellectual exchange. After the Christian reconquest of these regions, European scholars gained access to Arabic scientific and mathematical manuscripts preserved in Islamic libraries. These texts were translated into Latin, often by teams of Jewish, Christian, and Muslim scholars working collaboratively. The *Toledo School of Translators* played a vital role in rendering Arabic works by al-Khwārizmī, Thābit ibn Qurra, Abū Kāmil, and others into Latin, introducing European thinkers to algebra, algorithms, decimal numerals, and geometrical theories (Glick, 2020).

Sicily, under the Norman rulers during the 12th century, also became a conduit for this transmission. Due to its multilingual and multicultural environment, Sicily functioned as a hub where Arabic, Greek, and Latin scholarship could intersect. The royal court of King Roger II actively sponsored translation projects, which included mathematical texts on astronomy and geometry by Muslim scholars (Houzel, 2019). The impact of these translated Arabic texts on European mathematics was profound and long-lasting. One of the most notable figures influenced by them was Leonardo of Pisa, known as Fibonacci. After studying in North Africa, Fibonacci returned to Italy and, in 1202, wrote his famous work *Liber Abaci*. In it, he introduced the Hindu-Arabic numeral system and the concept of algorithms to a European audience, crediting the knowledge to "learned men of the East" (Knobloch, 2021). His use of Abū Kāmil's algebraic methods marked a direct intellectual inheritance from the Islamic mathematical tradition.

Moreover, the revival of classical knowledge in Europe during the Renaissance was significantly enabled by these Arabic–Latin translations. Scholars like Roger Bacon, Albertus Magnus, and later Descartes and Leibniz built on mathematical concepts that had been systematised, expanded, and refined by Muslim scholars' centuries earlier. The geometric clarity of Euclid, the logical structure of algebra, and the utility of trigonometry—all filtered through Arabic commentaries—laid the intellectual groundwork for the scientific revolution (Saliba, 2022).

Thus, the transmission of mathematical knowledge from the Islamic world to Europe was not merely a transfer of facts or formulas but a transformation in the way mathematics was conceptualised and taught. It helped shift Europe from a fragmented numerical system to a unified and efficient structure that enabled scientific and technological advancement.

Educational Relevance Today

The historical contributions of Muslim scholars to mathematics not only represent a significant intellectual heritage but also offer powerful pedagogical tools for modern education. By integrating these contributions into contemporary mathematics curricula, educators can foster both cognitive development and cultural literacy among students. Such integration promotes a more inclusive and globally-aware perspective of mathematical history. One of the key advantages of incorporating Islamic contributions is the opportunity to diversify mathematical narratives. Students often encounter mathematics as a Eurocentric discipline, with limited exposure to non-Western sources of mathematical innovation. However, recognising the foundational role played by scholars such as Al-Khwarizmi, Thabit ibn Qurra, and Ibn al-Banna broadens students' understanding and appreciation of mathematical development (Rashed, 2023; Youschkevitch, 2021). This inclusive approach not only enhances historical accuracy but also nurtures a sense of shared intellectual heritage across cultures.

Moreover, highlighting the pedagogical practices and problem-solving methods of early Muslim mathematicians—such as algebraic reasoning, algorithmic thinking, and practical applications in commerce and inheritance—aligns well with modern learning goals in STEM education. These practices can be introduced through classroom activities that replicate historical problems or explore original Arabic texts in translation, thereby promoting critical thinking and intercultural learning (Saliba, 2022).

Another educational benefit lies in the bridging of cultural appreciation and cognitive learning. When students from diverse backgrounds see themselves reflected in the curriculum through the inclusion of Islamic contributions, it fosters engagement and motivation. Simultaneously, such content reinforces the idea that mathematics is a universal language shaped by contributions from multiple civilisations over time (D'Ambrosio, 2020). Ultimately, embedding Islamic mathematical heritage within modern curricula is not merely about historical justice—it is about enriching the educational experience. It encourages learners to connect abstract concepts with real-world contexts and to value the global and cumulative nature of knowledge production.

Conclusion

The history of mathematics is deeply enriched by the contributions of Muslim scholars during the Islamic Golden Age. Pioneers like Al-Khwarizmi in algebra, Ibn al-Banna in applied mathematics, and Thabit ibn Qurra in geometry significantly shaped the field, preserving and building upon Greek and Indian knowledge while laying the foundation for European advancements during the Renaissance. Their work was not merely theoretical—it had practical applications in commerce, inheritance (Ilm al-Farā'id), architecture, and astronomy. The translation of these texts into Latin, especially through Al-Andalus and Sicily, influenced European thinkers like Fibonacci and catalyzed mathematical progress.

Despite their global impact, these contributions are often overlooked in modern education. Integrating them into contemporary curricula can foster historical literacy, cultural appreciation, and engagement in STEM. Further research and curriculum development are vital to highlight this shared human legacy and inspire future generations.

Suggestions

1. Educational policymakers should incorporate modules on Islamic mathematical heritage in both secondary and tertiary STEM programmes.
2. Curriculum developers and textbook authors should explicitly acknowledge the multicultural origins of major mathematical concepts.
3. Teacher education programs should include content on Islamic contributions to enhance interdisciplinary and culturally responsive pedagogy.
4. Libraries, museums, and archives should prioritize the digitization and exhibition of classical Islamic mathematical manuscripts for public engagement.
5. Scholars and educators should initiate research on underrepresented Islamic mathematicians and develop accessible educational resources based on their works.

References

Ahmed, S. (2021). *Islamic science and the making of the European Renaissance*. Cambridge University Press.

- Ahmed, Y. M. (2021). *Islamic contributions to science and mathematics*. Islamic Sciences Press.
- Al-Khalili, J. (2019). *Pathfinders: The golden age of Arabic science*. Penguin Books. Berggren, J. L. (2021). *Mathematics in medieval Islam: A cultural and intellectual journey*. Routledge.
- Burnett, C. (2020). *Arabic into Latin in the Middle Ages: The translators and their intellectual heritage*. Routledge.
- Burnett, C. (2021). *Arabic into Latin in the Middle Ages: The translators and their intellectual heritage* (2nd ed.). Routledge.
- Chemla, K., & Keller, A. (2023). *Mathematics and usefulness: Histories of mathematical practices in Islamicate societies*. Springer.
- D'Ambrosio, U. (2020). *Ethnomathematics: A historical and pedagogical perspective*. Springer.
- Dhanani, A. (2020). The Islamic legacy in mathematics: A review of contributions and pedagogical relevance. *International Journal of Islamic Thought*, 18(2), 34–47.
- Djebbar, A. (2022). Mathematics in the Maghreb: Ibn al-Banna and his legacy. *Journal of North African Studies*, 27(3), 345–362. <https://doi.org/10.1080/13629387.2021>.
- Eisenstein, E. L. (2021). *The printing revolution in early modern Europe* (2nd ed.). Cambridge University Press.
- Folkerts, M., & Plofker, K. (2022). Medieval Islamic mathematics: Foundations of a scholarly tradition. In *Encyclopaedia of the History of Science*. History of Science Society. <https://hssonline.org/ehst>
- Glick, T. F. (2020). *Islamic and Christian Spain in the early Middle Ages: Comparative perspectives on social and cultural formation*. Brill.
- Gutas, D. (2018). *Greek thought, Arabic culture: The Graeco-Arabic translation movement in Baghdad and early 'Abbasid society (2nd–4th/8th–10th centuries)* (2nd ed.). Routledge.
- Gutas, D. (2019). *Greek thought, Arabic culture: The Graeco-Arabic translation movement in Baghdad and early 'Abbasid society*. Routledge.
- Hogendijk, J. P. (2022). Abū Kāmil's treatment of irrational numbers. *Historia Mathematica*, 59(1), 10–29. <https://doi.org/10.1016/j.hm.2021.07.004>
- Hogendijk, J. P. (2022). Al-Khwārizmī's arithmetic: Translation and influence. *Archive for History of Exact Sciences*, 76(2), 121–140. <https://doi.org/10.1007/s00407-021->
- Iqbal, J. (2025). The use of geometry in Islamic architecture. *Scribd*. <https://www.scribd.com>
- Katz, V. J. (2022). *A history of mathematics: An introduction* (4th ed.). Pearson Education.
- Kennedy, E. S. (2023). Thābit ibn Qurra and the development of Islamic geometry. *Islamic Science Review*, 12(1), 45–63.

- Lamrabet, D. (2021). Ibn al-Banna and the practical mathematics of inheritance in the Islamic West. *Islamic Studies Journal*, 59(2), 189–204.
- Marrakchi, Y. (2023). Arithmetic in service of law: ‘Ilm al-Farā’id and Ibn al-Banna’s mathematical thought. *Arabian Journal of Mathematics and Law*, 5(1), 77–91.
- Nasr, S. H. (2021). *Science and civilisation in Islam* (New ed.). Harvard University Press.
- O’Connor, J. J., & Robertson, E. F. (2021). Muhammad ibn Musa al-Khwarizmi. *MacTutor History of Mathematics Archive*. University of St Andrews. <https://mathshistory.st-andrews.ac.uk/Biographies/Al-Khwarizmi/>
- Omar, S. A. (2022). *Science in medieval Morocco: Contributions of Ibn al-Banna al- Marrakushi*. Casablanca University Press.
- Purwanti, D. (2017). The thinking of Muhammad Ibn Muhammad ibn al-Hasan (al-Tusi) in trigonometry. *International Journal of Scientific & Technology Research*, 6(3), 129–133. <http://www.ijstr.org/final-print/mar2017.pdf>
- Rashed, R. (2020). *The geometry of Thābit ibn Qurra: From theory to application*. Brill Academic Publishers.
- Rashed, R. (2023). *Science and philosophy in medieval Islamic civilisation*. Routledge.
- Rashidi, S. M. M. (2023, February 27). Islamic art and its emphasis on symmetry. *LinkedIn*. <https://www.linkedin.com>
- Saliba, G. (2022). *Islamic science and the making of the European Renaissance*. MIT Press.
- Said, A. M. (2021). Revisiting the generalisation of the Pythagorean theorem: Thābit ibn Qurra’s legacy. *Journal of the History of Mathematics and Science*, 10(2), 211–230.
- Sesiano, J. (2021). *Islamic mathematics: Forgotten brilliance*. Springer Nature.
- Spherical astronomy. (2005). In *Wikipedia*. <https://en.wikipedia.org/wiki/Spherical>
- Spherical geometry: Concepts and uses. (2024). *Fiveable*. <https://library.fiveable.me/non->
- The Metropolitan Museum of Art. (n.d.). *Geometric design in Islamic art*. The Met. <https://www.metmuseum.org>
- University of St Andrews. (2018). *Nasir al-Din al-Tusi – Biography*. MacTutor History of Mathematics Archive. https://mathshistory.st-andrews.ac.uk/Biographies/Al-Tusi_Nasir/
- Youschkevitch, A. P. (2021). *The development of mathematics in the Arab world: 8th to 14th century*. World Scientific Publishing.