Batuthah: Jurnal Sejarah Peradaban Islam
Vol. 05 No. 01 (2026): 26-37
DOI: 10.38073/batuthah.v5i1.2698
Available online at: https://ejournal.uiidalwa.ac.id/index.php/batuthah

p-ISSN: 2986-1691
e-ISSN: 2985-6477

Mathematics In The Era Of The Abbasid Dynasty: Al-Khawarizmi's Contribution To The Development Of Modern Mathematical Thought In Baghdad 780-850 CE

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Received: 09, 2025. Revised: 01, 2026. Accepted: 02, 2026. Published: 03, 2026

Abstract:
The development of knowledge during the Abbasid Caliphate marked the emergence of the Islamic Golden Age, supported by political and institutional backing for intellectual activities. In this context, mathematics flourished through processes of translation, synthesis, and innovation, reaching its peak in the works of Al-Khawarizmi. This study examines the historical dynamics of the development of mathematics during the Abbasid Caliphate, focusing its analysis on Al-Khawarizmi's intellectual contributions. The research employs the historical method with a descriptive-analytical approach through literature-based data collection techniques. The research procedures include heuristics, interpretation, and synthesis of various sources discussing the development of algebra, arithmetic, and algorithms during that period. The findings indicate that Al-Khawarizmi made significant contributions to the systematic formulation of algebraic concepts, the introduction of the Hindu-Arabic numeral system, and the development of algorithmic methods that later became foundational to modern computer science. With the support of the Abbasid caliphs, particularly through the House of Wisdom in Baghdad, mathematics advanced rapidly and had a profound impact on Islamic civilization as well as the wider world.
Keywords: Abbasid Caliphate, Thought, Al-Khawarizmi, Mathematics.

Abstrak:
Perkembangan ilmu pengetahuan pada masa Kekhalifahan Abbasiyah menandai lahirnya era keemasan Islam yang ditopang oleh dukungan politik dan institusional terhadap aktivitas intelektual. Dalam konteks tersebut, ilmu matematika berkembang pesat melalui proses penerjemahan, sintesis, dan inovasi yang mencapai puncaknya pada pemikiran Al-Khawarizmi. Penelitian ini mengkaji dinamika sejarah perkembangan matematika pada masa Kekhalifahan Abbasiyah dengan memfokuskan analisis pada kontribusi intelektual Al-Khawarizmi. Penelitian ini menggunakan metode sejarah dengan pendekatan deskriptif-analitis melalui teknik pengumpulan data berbasis literatur sejarah. Langkah-langkah penelitian meliputi heuristik, interpretasi, dan sintesis terhadap berbagai sumber yang membahas perkembangan aljabar, aritmetika, dan algoritma pada masa tersebut. Hasil penelitian menunjukkan bahwa Al-Khawarizmi memberikan kontribusi besar dalam penyusunan konsep aljabar yang sistematis, pengenalan angka Hindu-Arab, serta pengembangan metode algoritma yang menjadi dasar dalam ilmu komputer modern. Dengan adanya dukungan dari para khalifah Abbasiyah, terutama melalui Baitul Hikmah di Baghdad, ilmu matematika berkembang pesat dan memberikan dampak signifikan terhadap peradaban Islam serta dunia secara luas.
Kata Kunci: Kekhalifahan Abbasiyah, Pemikiran, Al-Khawarizmi, Ilmu Matematika.

INTRODUCTION

The establishment of the Abbasid Dynasty began with the weakening of the Umayyad Dynasty, which eventually led to its collapse. Internal conflicts within the Umayyad Dynasty undermined its political legitimacy, creating an opportunity for the Abbasid Dynasty to emerge as the new caliphate of the Muslim community. The Abbasids had close familial ties to the Prophet Muhammad through the lineage of Banu Hashim, which strengthened their

claim to leadership. The first caliph of the Abbasid Dynasty was Abu al-Abbas As-Saffah, a descendant of Abbas ibn Abd al-Muttalib, the uncle of the Prophet Muhammad.[1] Compared to the leadership of the Umayyad Dynasty, the Abbasid revolutionary movement gained considerable sympathy from various segments of society, particularly from the *Shi'ah* community. This support arose from their promise to restore justice in accordance with the principles practiced during the era of the Rightly Guided Caliphs (*Khulafaur Rashidin*).[2]

Caliph Harun al-Rashid promoted scientific activities in Baghdad. The translation of major works from Greek and Sanskrit into Arabic not only preserved ancient knowledge but also stimulated new innovations in various fields of science. *Bayt al-Hikmah* (the House of Wisdom) became a center where Muslim and non-Muslim scholars gathered to discuss and collaborate across different disciplines.

The Abbasid Dynasty became a center of world civilization that significantly influenced Europe through a centuries-long process of knowledge transfer. This advancement demonstrates the crucial role of the state and its leaders in fostering innovation and sustaining intellectual development.[3]

One of the scholars who played an important role in this development was Al-Khawarizmi. He is widely recognized as a pioneer in algebra and in the development of the decimal numeral system. His work, *Al-Kitab al-Mukhtasar fi Hisab al-Jabr wa al-Muqabalah*, became a primary reference for solving linear and quadratic equations. It was later translated into Latin and became a foundational text for the development of mathematics in Europe.[4]

During the reign of Caliph Al-Ma'mun, support for scientific advancement was further strengthened. He even established teams of scholars to study, translate, and develop knowledge in astronomy, mathematics, medicine, and philosophy. Prominent figures such as Al-Khawarizmi, known as the pioneer of algebra and algorithms, flourished within this vibrant intellectual environment.[5]

Various previous studies related to the historical analysis of Al-Khawarizmi's thought have been examined through a number of relevant literatures. The review indicates that although several earlier studies have addressed this theme, their discussions remain insufficiently in-depth and lack a specific focus on Al-Khawarizmi's intellectual contributions. One such work is by Mohd Syahmir Alias entitled *Analisis Teleologi Penyelidikan Sains Berdasarkan Mukadimah Adikarya Al-Khawarizmi, Ibn Al-Haytam dan Al-Biruni*. Although this research covers three major figures in Islamic science, the discussion of Al-Khawarizmi's contributions is not elaborated in detail due to the broad scope of the

[1] Rizem Aizid, *Sejarah Peradaban Islam Terlengkap, Diva Press* (Yogyakarta, 2015).

[2] Nunzairina, "Dinasti Abbasiyah: Kemajuan Peradaban Islam, Pendidikan Dan Kebangkitan Kaum Intelektual," *Jurnal JUSPI (Jurnal Sejarah Pendidikan Islam)* 3, no. 2 (2020), https://doi.org/https://doi.org/10.30829/juspi.v3i2.4382.

[3] Aldewo Dillon Perkasa et al., "Penemuan Muhammad Bin Musa Al Khawarizmi," *Jurnal Soshum Insentif* 4, no. 2 (2021): 130–36, https://doi.org/10.36787/jsi.v4i2.610.

[4] Dkk Fatia Rahmanita, "Ulumuddin : Jurnal Ilmu-Ilmu Keislaman," *Al-Khawarizmi Serta Kontribusinya Untuk Perkembangan Sains Modern* 13 (2023): 297–312, https://doi.org/https://doi.org/10.47200/ulumuddin.v13i2.2045.

[5] Fathurrahman Muhtar, "Abu Abdullah Ibn Musa Al-Khawarizmi (Pelopor Matematika Dalam Islam)" 7, no. 2 (2014): 82–97, http://jurnalbeta.ac.id.

topic. Another study is by Devina Juniar Ruhiat entitled *Sejarah Konsep Matematika dalam Peradaban Islam dan Implementasinya dalam Kehidupan*. This work describes the development of mathematics since the early Hijri period and its application in various aspects of life, such as inheritance distribution and zakat calculation. The study explicitly highlights the connection between Islamic concepts and Al-Khawarizmi's discoveries.

The uniqueness of the present study lies in its focus, which goes beyond a merely descriptive biographical account of Al-Khawarizmi. Instead, it specifically examines the methodological transformation he initiated from the rigid system of Greek geometry to a unifying and practical system of algebra under the institutional framework of *Bayt al-Hikma*. Al-Khawarizmi not only formulated computational techniques but also laid philosophical foundations in his book *Al-Jabr wa al-Muqabalah*. This aspect of originality is particularly significant because it demonstrates how religious motivations and the practical needs of society at the time stimulated the emergence of a new branch of knowledge. As stated by Shinta Sri Wahyuni, Al-Khawarizmi's thought reflects the integration of scientific dimensions and the values embodied in Muslim scholars' contributions in responding to the challenges of their era.[6]

While much of the literature primarily emphasizes the technical mathematical aspects of his work, this article offers a distinctive perspective by highlighting the dimension of intellectual history namely, how the political policies of the Abbasid Caliphate contributed to the standardization of the numeral system that we continue to use today.[7] The main objective of this study is to remap the transmission of knowledge from ancient civilizations to the Abbasid period in order to provide a deeper historical perspective on the role of Muslim scholars in shaping modern logical reasoning.[8] Therefore, the author intends to examine the development of mathematics and to analyze Al-Khawarizmi's contributions to its advancement during that period.

RESEARCH METHOD

This study employs the historical method with a qualitative research approach that is descriptive-analytical in nature to systematically uncover facts regarding the development of mathematics during the Abbasid Caliphate. The research procedure begins with the heuristic stage, in which the author collects various primary literature sources such as the works of Al-Khawarizmi, manuscript documents, and secondary sources including journal articles and relevant books related to Al-Khawarizmi's contributions as well as the institutional role of *Bayt al-Hikmah*.

The collected documentary data are then processed through source criticism or verification. At this stage, the author selects and evaluates narratives from the gathered documents to ensure the authenticity and reliability of the data before proceeding to the interpretation phase. During the interpretation stage, the author applies content analysis

[6] Shynta Sri Wahyuni Ginting, Ahmad Syukri, and Salminawati, "Science And Technology In The Qur'an (Study Of Islamic Educational Philosophy)," *Reflektika* 18, no. 1 (2023), https://doi.org/https://doi.org/10.28944/reflektika.v18i1.1171.

[7] Masjudin and Selamet Ridwan, "Pola Dan Perkembangan Pendidikan Islam Pada Masa Dinasti Abbasyiah Masjudin," *Ta'dib* 15, no. 2 (2017): 73–86, https://doi.org/https://doi.org/10.37216/tadib.v15i2.186.

[8] Moh. Nurhakim, *Sejarah Perkembangan Peradaban Islam*, 2003.

techniques to examine the relationship between the intellectual policies of the caliphate and the originality of Al-Khawarizmi's ideas in the fields of algebra, arithmetic, and algorithms.

All analytical results are then systematically organized through the historiographical stage to produce a comprehensive historical narrative concerning Al-Khawarizmi's significant role in shaping the foundations of modern mathematics.

RESULTS AND DISCUSSION

Al-Khawarizmi in the History of the Development of Science

Al-Khawarizmi, whose full name was Abu Ja'far Muhammad ibn Musa al-Khwarizmi, was born around 780 in Khwarizm, a region now known as Khiva, Uzbekistan. Although historical records provide very limited primary information about the names of his parents, the designation "ibn Musa" indicates that his father's name was Musa. Al-Khawarizmi spent his childhood and youth in an environment deeply rooted in scholarly traditions in Khwarizm before eventually undertaking an intellectual journey (*rihlah*) to Baghdad, which was the center of Islamic civilization at the time. In Baghdad, he matured into a distinguished scholar under the patronage of Caliph Al-Ma'mun of the Abbasid Caliphate. He passed away around 850 after dedicating his life to the advancement of science.[9]

Al-Khawarizmi's intellectual devotion reached its peak when he was appointed as a member and later a leading figure of the *Bayt al-Hikma* in Baghdad. This institution was not merely a library but also a center for research, astronomical observation, and large-scale translation efforts that brought together scientific knowledge from Greek, Indian, and Persian traditions.[10] Within this highly conducive scholarly environment, Al-Khawarizmi meticulously worked on standardizing numerical systems and computational methods. One of his most remarkable achievements was the introduction of the concept of the algorithm a systematic procedure for solving mathematical problems whose name is derived from the Latinized form of his name, "Algoritmi." This contribution became a fundamental foundation for logical programming methods and the development of modern computer science.[11]

The Development of Mathematics and Intellectual Dynamics During the Abbasid Caliphate 750-1258

The period of the Abbasid Caliphate was a golden age marked by the rapid development of knowledge and intellectual culture. The Abbasid caliphs strongly supported scholarly activities by establishing and funding scientific institutions that functioned as centers of learning and research, particularly in Baghdad, the capital of the caliphate.[12] One of the most important institutions was the *Bayt al-Hikmah* (House of Wisdom), which became the center of the Translation Movement an effort to translate scientific works from Greek, Persian, and Indian languages into Arabic. This movement provided access to

[9] Nurul Huda, "Perkembangan Ekonomi Dan Ilmu Pengetahuan Pada Masa Dinasti Abbasiyah," *Jurnal Ekonomi Dan Konseling* 1, no. 2 (2021): 25.

[10] Suroaya, "Madrasah Nizamiyah Dan Bait Al-Hikmah (Dua Institusi Pendidikan Ikonik Dalam Sejarah Peradaban Islam)," *Jurnal El-Hikam* 8, no. 1 (2015): 112.

[11] Siti Maryam, "Sumbangan Al-Khwarizmi Dalam Perkembangan Matematika," *Mapan: Jurnal Matematika Dan Pembelajaran* 4, no. 2 (2016): 230.

[12] Ainur Riska Amalia, "Sejarah Peradaban Islam : Perkembangan Ilmu Pengetahuan Pada Masa Pemerintahan Diinasti Bani Abbasiyah," *Rihlah: Jurnal Sejarah Dan Kebudayaan* 10, no. 01 (2022): 53–64, https://doi.org/10.24252/rihlah.v10i01.38405.

foundational classical mathematical texts.[13]

In the field of mathematics, scholars under the Abbasid Caliphate not only translated Greek works such as Elements by Euclid and Almagest by Ptolemy, but also critically examined, developed, and synthesized this knowledge within the Islamic intellectual tradition.[14] For example, the Indian numeral system, which included the concept of zero, was adopted and refined into what later became known as the Hindu-Arabic numeral system. This system proved to be far more efficient for calculation than the previously used Roman numerals.[15]

Prominent intellectual figures such as Muhammad ibn Musa al-Khawarizmi played a key role in the advancement of mathematics. Al-Khawarizmi's monumental work on algebra is considered one of the most influential mathematical contributions of the classical Islamic world and laid the foundation for modern algebra.[16] In addition, the contributions of other Muslim scholars in geometry, trigonometry, and number theory demonstrate the strong intellectual dynamism of the period. These mathematical concepts were later transmitted to the Western world and significantly influenced its scientific development.[17]

Overall, the Abbasid Caliphate represents a period in which mathematics evolved from merely translating and preserving classical knowledge into becoming a source of original scientific innovation with far-reaching impact. This intellectual tradition not only expanded the scope of mathematical knowledge but also established methodological foundations for the subsequent development of global science.[18]

The Concept of Al-Khawarizmi in Formulating Modern Mathematics

Muhammad ibn Musa al-Khawarizmi is recognized in the historiography of science as a central figure who formulated the conceptual foundations of modern mathematics through the systematization of algebraic and arithmetic methods in the 9th century. In his monumental work, *Al-Kitab al-Mukhtasar fi Hisab al-Jabr wa al-Muqabala*, he did not merely compile computational techniques, but developed logical and sequential procedures for solving linear

[13] Alya Rahmadani Harahap et al., "Sejarah Peradaban Islam Dalam Perkembangan Matematika," *Bhinneka: Jurnal Bintang Pendidikan Dan Bahasa* 02, no. 01 (2024): 173–79, https://doi.org/https://doi.org/10.59024/bhinneka.v2i1.651.

[14] Devina Juniar Ruhiat et al., "Sejarah Konsep Matematika Dalam Peradaban Islam Dan Implementasinya Dalam Kehidupan," *Awwaliyah: Jurnal PGMI* 05, no. 02 (2022): 129–36, https://doi.org/https://doi.org/10.58518/awwaliyah.v5i2.1116.

[15] Ruhiat et al.

[16] Akhdian and Najla Nur Salima, "Analisis Perkembangan Matematika Dengan Sejarah Islam Yang," *Religion : Jurnal Agama, Sosial, Dan Budaya* 3, no. 3 (2024): 309–18, https://maryamsejahtera.com/index.php/Religion; Putri Rahma Dani and Amril, "Perkembangan Ilmu Di Dunia Islam Klasik (Abbasiyah)," *Multidisciplinary Indonesian Center Journal (MICJO)* 02, no. 01 (2025): 452–58, https://doi.org/https://doi.org/10.62567/micjo.v2i1.431.

[17] Dede Nurjanah et al., "Kontribusi Sejarah Aljabar Babilonia Dan Aljabar Arab Terhadap Berpikir Aljabar," *Jurnal Analisa* 7, no. 2 (2021): 112–23, https://doi.org/https://doi.org/10.15575/ja.v7i2.8231.

[18] Saad Jamiu Abdulazeez Saad Jamiu, Ally Hammed Bello, and Qasim Ambali Malik, "Legacy of Muslim Scholars in Advancing Arithmetic and Geometry During the Islamic Golden Age: Modern Lessons for Stem Education," *Kontagora Journal of Mathematics* 1, no. 1 (2025): 151–64, https://doi.org/https://doi.org/10.5281/zenodo.17366453; Ibnu Rusydi, Didin Saepudin, and Murodi, "The Golden Age of Islamic Intellectuals and The Development of Science During The Abbasid Dynasty," *Tafkir: Interdisciplinary Journal of Islamic Education* 4, no. 4 (2023): 599–609, https://doi.org/10.31538/tijie.v4i4.726.

and quadratic equations, thereby establishing a methodological structure that later became a defining characteristic of modern mathematics.[19]

Historians of mathematics affirm that Al-Khawarizmi's approach marked a significant transition from the Greek mathematical tradition, which was oriented toward geometry, to a more abstract symbolic and procedural approach.[20] In the analysis of Roshdi Rashed, Al-Khawarizmi's algebraic system is even regarded as a milestone in the birth of algebra as an independent discipline, as he treated equations as objects of study in their own right rather than merely as tools of geometry. Furthermore, his contribution to introducing the Hindu-Arabic numeral system and place-value computation methods enabled far greater computational efficiency than Roman numerals, thereby paving the way for the development of practical mathematics in trade, astronomy, and administration.[21]

Modern scholarship also emphasizes that the algorithmic methods he employed namely, systematic step-by-step procedures became a conceptual model for modern computational logic, and his name was immortalized in the term "algorithm" in the Western scientific tradition.[22] Therefore, Al-Khawarizmi's thought represents not only a historical contribution but also an epistemological foundation that shaped mathematics as a deductive, systematic, and applied science up to the modern era. Another important innovation was the revolutionary use of zero within the numeral system, adopted from the Indian mathematical tradition and widely disseminated throughout the Islamic world and the West.[23]

Contribution of Al-Khawarizmi to Mathematics

In the field of mathematics, Al-Khawarizmi made fundamental contributions through the formulation of a structured system of algebra as well as algorithmic calculation methods that later became the foundation for the development of scientific mathematics in subsequent periods.[24]

Al-Khawarizmi made significant contributions across various branches of knowledge, including geography, astrology, astronomy, mathematics, and cartography.[25] Through a systematic and methodological approach, he laid a strong foundation for the advancement of these sciences, which later developed further in trigonometry, algebra, and other disciplines.[26]

Development of Algebra In his renowned work, *Al-Kitab al-Mukhtasar fi Hisab al-Jabr wa al-Muqabala* (The Compendious Book on Calculation by Completion and Balancing), Al-Khawarizmi introduced the fundamental concepts of algebra as an independent branch of mathematics. He developed systematic methods for solving quadratic equations, which later became the basis for the study of modern algebra. The book was translated into Latin in the 12th century under the title *Liber algebrae et almucabala*, and it served as a primary reference for mathematics education in Europe until the 16th century.

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[19] Carl B. Boyer, *A History of Mathematics* (New York : Wiley, 1991).

[20] Victor J. Katz, *A History of Mathematics* (Addison-Wesley, 1998).

[21] J. L. Berggren, *Episodes in the Mathematics of Medieval Islam* (New York : Springer-Verlag, 1986).

[22] Charles Coulston Gillispie, *No Title* (New York, Scribner, 1970).

[23] Akhdian and Salima, "Analisis Perkembangan Matematika Dengan Sejarah Islam Yang."

[24] Carl B. Boyer, *A History of Mathematics*.

[25] Aufa Nawallia, "Kontribusi Ilmuwan Muslim Dalam Pembentukan Matematika Dan Perkembangan Matematika Dalam Sejarah Peradaban Islam," *Religion : Jurnal Agama, Sosial, Dan Budaya* 3, no. 2 (2024): 202–12, https://doi.org/https://doi.org/10.55606/religion.v3i2.934.

[26] Dillon Perkasa et al., "Penemuan Muhammad Bin Musa Al Khawarizmi."

Development of Algorithms The word "algorithm" is derived from the name of Al-Khawarizmi, who was renowned for his systematic methods of solving mathematical problems. The algorithmic concepts pioneered by Al-Khawarizmi did not develop in isolation, rather, they were supported by a conducive intellectual environment such as the House of Wisdom in Baghdad, a major center of research and scientific translation where he worked and composed his mathematical treatises.

Historians of science emphasize that this institution played a crucial role in bringing together Greek, Indian, and Persian mathematical traditions, thereby enabling the development of computational methods, trigonometric tables, and more precise astronomical techniques, which later had a broad influence on the advancement of mathematics in the Islamic world and medieval Europe.[27]

Thus, the progress in algorithmic concepts and mathematical computation developed by Al-Khawarizmi was not solely the result of individual brilliance, but also a reflection of the scientific ecosystem of the Abbasid Caliphate, which fostered research, intellectual synthesis, and methodological innovation.

The Role of Al-Khawarizmi in the Development of Mathematics

In the history of mathematical development, Al-Khawarizmi played a fundamentally important role as a pioneer of modern algebra through his systematic approach, which distinguished mathematics as an independent scientific discipline rather than merely a computational technique.[28] His monumental work, *Al-Kitāb al-Mukhtaṣar fī Ḥisāb al-Jabr wa al-Muqābala*, introduced systematic methods for solving linear and quadratic equations, forming the foundation of algebra as a formal field of study.[29]

He is also known for contributing to the spread of the Hindu-Arabic numeral system, including the concept of zero and the place-value system, which replaced Roman numerals and greatly expanded the scope of mathematical calculation in the Islamic world and later in Europe.[30] Furthermore, the term "algorithm," derived from the Latinized form of his name, *Algoritmi*, became a universal concept that underlies modern computation and programming.[31]

Al-Khawarizmi also helped integrate the mathematical heritage of Greek and Indian traditions into a more structured scientific framework, enabling the advancement of disciplines such as geometry and trigonometry through the development of accurate

[27] Dimitri Gutas, *Greek Thought, Arabic Culture : The Graeco-Arabic Translation Movement in Baghdad and Early 'Abbāsid Society (2nd-4th/8th-10th Centuries)* (London ; New York : Routledge, 1998); George Saliba, *Islamic Science and the Making of the European Renaissance*, 1st ed. (Cambridge, Massachusetts, USA: The MIT Press, 2007).

[28] Yulyanti Harisman and Putri Sania, "Perkembangan Matematika Muslim Abad Ke-8 Kontribusi Al-Khawarizmi Terhadap Al-Jabar," *Euclid* 12, no. 2 (n.d.): 46–54, https://doi.org/https://jurnal.ugj.ac.id/index.php/Euclid/article/view/11857.

[29] Harisman and Sania.

[30] Dr. N. Akmal Ayyubi, "Contribution of Khwârazmî to Mathematics and Geography," in *Foundation for Science Technology and Civilisation*, 2006, 1–9.

[31] Ida Rahmawati et al., "Al-Khwarizmi , Algebra , and Inspiration from the Qur ' an : A Historical Study of Islamic Mathematics," *International Islamic Studies Journal* 01, no. 02 (2025): 80–87, https://doi.org/https://journalkhd.com/ojs/index.php/issj/article/view/531/346.

numerical tables.[32]

His contributions were further strengthened by the intellectual synergy fostered by the House of Wisdom in Baghdad, a major center of translation and scholarly research. This environment allowed his works to be preserved, studied, and later translated into Latin in the 12th century, significantly influencing the European Renaissance.[33]

Thus, Al-Khawarizmi's contributions extend beyond algebraic theory; they include the establishment of a logical, systematic, and integrated methodology in mathematics that continues to influence the modern era.

The Impact of Al-Khawarizmi's Thought on Modern Mathematics

The impact of Al-Khawarizmi's thought on modern mathematics is clearly seen in the transformation of algebra from merely a calculation technique into an independent branch of mathematics with its own theoretical framework. In computer science, his contributions gave rise to the concept of algorithms, which serve as the foundation of programming and artificial intelligence. In finance and economics, the decimal system and algebraic calculations are widely used in financial analysis. In technology and science, mathematical methods are applied extensively in physics, engineering, and astronomy.

The development of Al-Khawarizmi's thought not only influenced pure mathematics but also had a broad impact on various modern disciplines. In the field of computer science, the step-by-step procedural concept derived from Al-Khawarizmi's mathematical problem-solving methods became the foundation for the concept of the algorithm, a logical structure of instructions that now underpins modern programming and artificial intelligence.

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In economics and finance, the use of the decimal number system and algebraic calculation techniques enabled the development of quantitative analytical methods, such as interest calculation, financial statistics, and economic mathematical models that require high-precision numerical operations.[35]

Meanwhile, in science and technology, the systematic mathematical approach formulated in his works on algebra laid the groundwork for the formulation of equations in physics, engineering, and astronomy, as these disciplines rely on symbolic models and mathematical equations to explain natural phenomena quantitatively.[36]

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[32] Harisman and Sania, "Perkembangan Matematika Muslim Abad Ke-8 Kontribusi Al-Khawarizmi Terhadap Al-Jabar."

[33] Axl Ferrari Fatahillah, Shafa Desliana Dinanti, and Rizki Amrillah, "The Role of Mathematics in Improving the Quality of Education Based on Modern Islamic Civilization," *Al Khawarizmi: Jurnal Pendidikan Dan Pembelajaran Matematika* 8, no. 1 (2024): 24–32, https://doi.org/https://doi.org/10.22373/jppm.v8i1.22971.

[34] Berggren, *Episodes in the Mathematics of Medieval Islam*.

[35] Roshdi Rashed, *The Development of Arabic Mathematics: Between Arithmetic and Algebra*, 1st ed. (Dordrecht: Kluwer Academic Publishers, 1994).

[36] Muhammad ibn Musa Al-Khwarizmi and Friedrich August Rosen, *The Algebra of Mohammed Ben Musa* (London, United Kingdom: Printed for the Oriental Translation Fund and sold by J. Murray, London;

Thus, the influence of Al-Khawarizmi's thought is not limited to classical mathematical theory but extends into a methodological framework that supports the advancement of modern science across various fields.

These works demonstrate that the most significant development of mathematics in the Arab region began with the emergence of the works of Al-Khawarizmi, which are widely recognized as marking the beginnings of algebra. It is important to understand how profound the influence of this concept was at the time, representing a revolutionary shift from Greek mathematical concepts, which were essentially based on geometric theory.[37]

Algebra emerged as a unifying theory that allowed rational and irrational numbers, geometric magnitudes, and other quantities to be treated as algebraic objects. It is a branch of mathematics that developed from arithmetic. Its purpose is to determine unknown values based on known data, provided that a relationship exists between them. In the Islamic scholarly tradition, besides algebra, there were also the disciplines of *Ilm al-Hisab* (arithmetic) and *Handasah* (geometry).[38]

One important aspect of the development of algebra was its ability to enable mathematics to be applied more systematically through structured methods or step-by-step procedures that had not previously been known.[39]

Thus, Al-Khawarizmi's contribution in developing and disseminating the Hindu-Arabic numeral system, including the concept of zero, had a significant impact on the history of mathematics and science, forming the foundation for the advancement of modern technology.

CONCLUSION

Based on historical studies and literature analysis, it can be concluded that the development of mathematics during the Abbasid Caliphate experienced remarkable progress due to strong political support, institutional backing, and a conducive intellectual culture, particularly through the establishment of the House of Wisdom in Baghdad. This period functioned not only as an era of knowledge transmission from Greek, Indian, and Persian civilizations, but also as a phase of transformation and innovation that gave rise to new paradigms in mathematics. Mathematics evolved from merely an activity of translation into a systematic and applicable scientific discipline with a clear methodology.

Al-Khawarizmi emerged as a central figure who made fundamental contributions to the formation of modern mathematics. Through his work, *Al-Kitāb al-Mukhtaṣar fī Ḥisāb al-Jabr wa al-Muqābalah*, Al-Khawarizmi established algebra as an independent branch of knowledge, separate from the dominance of Greek geometric approaches. He introduced logical and procedural methods for solving equations, which later became the precursor to symbolic approaches in modern mathematics. Moreover, his role in disseminating the Hindu-

Parbury, Allen & Co., Calcutta; Treuttel & Würtz, Paris; E. Fleischer, Leipzig, 1831).

[37] muhtar, "Abu Abdullah Ibn Musa Al-Khawarizmi (Pelopor Matematika Dalam Islam)."

[38] Achmad Mulyadi, "Pemikiran Al-Khawarizmi Dalam Meletakkan Dasar Pengembangan Ilmu Astronomi Islam," *International Journal Ihya' 'Ulum Al-Din* 20, no. 1 (2018): 63–86, https://doi.org/10.21580/ihya.20.1.2782.

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Arabic numeral system, including the concept of zero and place value, brought about a major revolution in the efficiency of mathematical calculation, which was subsequently widely adopted throughout the Islamic world and Europe.

Furthermore, the concept of the algorithm, rooted in Al-Khawarizmi's systematic mode of thinking, became an epistemological foundation for the development of computer science and modern technology. Thus, Al-Khawarizmi's contributions not only influenced the development of classical mathematics but also shaped the methodological framework of modern science, emphasizing logic, systematic structure, and practical application. Therefore, this study affirms that Al-Khawarizmi's mathematical thought serves as an essential bridge between the classical scientific tradition and modern mathematical reasoning that remains relevant to this day.

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