Islamic Mathematics: Influence & Importance

Jules Hunter

This report covers the mathematical developments of medieval Islam during the Islamic Golden Age (622~1300 C.E.), and the importance of accurately teaching the origins of mathematics in education today. The Islamic Golden Age featured significant advancements in myriad specialized disciplines, including art, sociology, science, and economics. The Baghdad "House of Wisdom" was a cornucopia of global knowledge, and the nexus of an initiative to translate and synthesize all the knowledge in the world into Arabic, the lingua franca of most scholars, during this time. These efforts are known as the Translation Movement. Among the droves of knowledge accumulated under the Islamic caliphate were significant contributions to the field of mathematics, particularly in algebra and arithmetic, that have profoundly influenced the concept and application of mathematics in the West. However, these origins of the math that we teach in secondary education is rarely mentioned. The oft implied consequence of leaving students without this global orientation is a conception of knowledge as a very Western, white, and masculine—a conception of knowledge being given as a gift from God, as opposed to developed through a community effort. This can worsen the performance of minority students in math classes, in addition to alienating all students from the cultural roots of the material they are learning, making it more difficult to form associations and to care about the subject. The acknowledgement of the contributions of Islamic mathematicians to modern curriculums would be beneficial for student engagement and performance. Islamic mathematicians should be included alongside other important mathematical and scientific figures in secondary education,

because their overall contributions during the Islamic Golden Age were essential to the formation of modern mathematics as we understand it today.

Though dubbed “Islamic mathematics” in this paper, contributions to science during this period in the Middle East were diverse, originating with a collection of Persian, Arab, Berber, Moorish, Turkic, Afghan, and Indian people, not all of whom were Muslim. The Islamic community, especially in its Golden Age, spanned regional and ethnic groupings, and was tolerant of many other religious traditions including Christians, Jews, and Zoroastrians. Confusion may arise as a result of the linguistic situation of “Islam” as a veritable homonym, described well by historian Bernard Lewis in remarks for an article by Carenegie Council for Ethics in International Affairs:

> "In English we use the word “Islam” with two distinct meanings, and the distinction is often blurred and lost and gives rise to considerable confusion. In the one sense, Islam is the counterpart of Christianity; that is to say, a religion in the strict sense of the word: a system of belief and worship. In the other sense, Islam is the counterpart of Christendom; that is to say, a civilization shaped and defined by a religion, but containing many elements apart from and even hostile to that religion, yet arising within that civilization”(Lewis).

This paper uses “Islam” in the latter sense, referring to the multicultural community that spread across the Middle East, Central Asia, and North Africa, sprung from Muhammad’s original Muslim community in Arabia. The meaning of Islam in its historical context is more than a profession of faith: as noted in the book No God But God, “This was also an era in which religion and the state were one unified entity. […] Your religion was your ethnicity, your culture, and your social identity; it defined your politics, your economics, and your ethics. More than anything else, your religion was your citizenship”(Aslan, 246).

The contributions of Islamic intellectuals have changed the knowledge base and practice of scholarship in the West. As Islamic history has been brought to light in the modern American and Western European academic consciousness, it has become certain that “many of the ideas which were previously thought to have been brilliant new conceptions due to European mathematicians of the 16th, 17th, and 18th centuries are now known to have been developed by Arabic/Islamic mathematicians around four centuries earlier”(O’Conner, Robertson). Mathematicians like Muhammad bin Mūsa al-Khwārizmī, Al-Mahani, and Al-Hassār made important contributions to global mathematical knowledge that is taught at the primary, K-12 level. “In many respects,” state math historians J. J. O'Conner and E. F. Roberson, “the mathematics studied today is far closer in style to that of Islamic mathematics than to that of Greek mathematics”(O’Conner, Robertson). And yet, many students who graduate high school are completely unaware of the academic contributions of these ethnic scholars, though most graduate with a basic knowledge of foundational thinkers in every other subject, having heard extensively about Shakespeare & Fitzgerald, Charles Darwin & Gregor Mendel, John Dalton & Dmitri Mendeleev. This builds a false conception of who, and what, makes a capable STEM professional. The mathematical figures we teach about are mentioned only briefly, and the limelight goes to Pythagoras and Newton—geometry and physics, skipping over prominent figures in algebra and arithmetic, which make up the belt of the curriculum. These students go on to attend university, not knowing that they are continuing in the tradition of the academic degree-granting university that was established in the medieval Islamic world! Indeed, the first universities to issue diplomas were the medical university-hospitals, Bimaristan, under the Islamic caliphate, and Al-Azhar University in Cairo is generally considered the first fully fledged university in the world. There is undoubtedly a gap in our knowledge here. I believe that, like we

are required to learn about chemists who first modeled the atom, biologists who experimented and solidified the theory of natural selection, and physicists like Newton, the fundamental mathematical contributions of the Islamic Golden Age to algebra and arithmetic should be a minimum addressed by standard primary education curriculums.

The algebra developed during the Islamic Golden Age gave rise to modern algebraic thinking by introducing fundamental logical concepts. Muhammad inn Mūsā al-Khwārizmī was a Muslim Persian mathematician who lived from ~780-850 C.E., and wrote several books on math and astronomy, inducing his most famous work, *Al-jabr wa'l muqabalah*. This book imparted the cardinal logic of solving static equations, which he termed "reduction" and "balancing." That is to say, he elucidated the transposition of subtracted terms to the other side of an equation using the logic of canceling like-terms, which begins to be taught in the 6th grade in the U.S. He used the current established mathematical method of geometric proofs to establish his logic with linear equations, and then exhaustively explained the algebraic solution for solving polynomials up to the second degree (quadratic equations with positive roots). Notably, he also originated the method of completing the square, which readers may remember from high school math classes. Al-Khwārizmī's methods became known as "algebra" from the Arabic "al-jabr". Thus, Al-Khwarizmi is widely labeled "the father of algebra" for the essential principles of his logical methods of solving equations and for his ability to teach algebra in its elementary form, distinct from other disciplines—laying the conceptual foundation for all developments of abstract algebra. Islamic algebra was a revolutionary transition beyond the Greek concept of mathematics, which was primarily geometric, and it widened our mathematical concept by allowing mathematics to be applied recursively. The works of Islamic mathematicians, especially

Al-Khwārizmī's attempts to classify types of equations and methods for solving them, are the foundation of algebra curricula to this day.

Islamic mathematical knowledge would, of course, not have been nearly as influential without a strong foundation; Egyptian, Indian, and Babylonian mathematics all contributed to the development of early Islamic mathematics. Scholars believe that a combination of Hindu, Mesopotamian, and Hellenistic influences gave rise to Islamic strides in algebraic calculation. The most influential of these, the Hindu numerals [1-9], was incorporated into the melting pot of scholarly knowledge stewing under the Islamic caliphate, likely through an embassy in India that brought Brahmagupta's book *Brahmasphuta-siddhanta* translated into Arabic as *Sindhind*. Al-Khwārizmī and the Arab mathematician Al-Kindi both used the Hindu numerals in their books, which were chiefly responsible for their later diffusion throughout the Middle-East and into the West.

Islamic contributions to arithmetic built on Indian and Egyptian systems in the 10th century, further expanding the overall influence of Islam in the global mathematical community. Middle-Eastern mathematicians used decimal point notation to extend the numeral system to include fractions. Only recently has the Western world opened up to this and many other contributions of Islamic scholars, evidenced by Dirk Jan Struik's statement in The Art of Arithmetic at Ǧamšīd, "The introduction of decimal fractions as a common computational practice can be dated back to the Flemish pamphelet De Thiende, published at Leyden in 1585 […] by the Flemish mathematician Simon Stevin"(Jan Struik). Once attributed to Dutch and French mathematicians, the truth is that decimal fractions originated five centuries before in Baghdad. In addition to expanding the decimal system, Islamic mathematicians also made notable contributions to the field of arithmetic, including the work of Abū Kāmil, who was the

first scholar to treat irrational numbers as algebraic objects that could be used to solve equations, Persian mathematician Al-Mahani, who added to the Arabic concept of a real number, a merging of the concepts of "number" and "magnitude," and Al-Hassār, who developed the modern symbolic notation for fractions, that presents the numerator and denominator separated by a horizontal bar during the 12th century. Al-Hassār's fractional notation appeared a century later in the work of Fibonacci. Many of the contributions of Islamic mathematicians would not have been possible without the baseline conceptual logic of Islamic algebra developed by Al-Khwārizmī.

Despite the multitude of important contributions of Islamic mathematicians to modern Western mathematics, our curriculum never mentions the contributions of influential mathematicians such as Al-Khwārizmī and Al-Hassār. Tidge Holmberg describes his core-curriculum liberal arts mathematics education thus: "We read Euclid, Apollonius, Ptolemy, and then Descartes, Newton, Copernicus. The cultural continuity was clear: the Ancient Greeks and the Modern Western Europeans. The intervening centuries, however, were silent"(Holmberg). This gap in our education system is critical, because the lack of diverse, comprehensive recognition of multicultural contributions to academia is a contributing factor in minority student performance gaps. In an article about culturally rich curriculum changes for the Fordham Institute, it was stated that the current "curriculum rarely succeeded in getting me to question, reflect, and engage with the material I was learning on a deep level"(Kim). Consistently, a lack of engagement with diverse cultural backgrounds and influences on school subjects leads to feelings of alienation and worse comprehension of material for students. This is evidenced by David Guillemette in his study on the impact of dépaysement épistémologique (epistemological disorientation) in secondary school education. He concludes that familiarity with the history of mathematics, "particularly with the use of original sources, […] encouraged

empathy from students towards the authors and their future learners"(Guillemette, 1). So it is beneficial for students to be familiar with the origins of the material they are being taught, because it helps them to build associative connections about the information in their minds.

Overall, the contributions of Islamic mathematicians during the Islamic Golden Age were essential to the formation of modern mathematics as we understand it today. This is not even to mention the debt owed to Islamic translators for their work preserving ancient Greek texts that would otherwise have been lost to time. The simple acknowledgement of the contributions of Islamic mathematicians to modern, Western math curriculums would be beneficial for student engagement as well as performance, so Islamic mathematicians should be included alongside other important mathematical and scientific figures in secondary education.

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