International Journal of Science and Research (IJSR)
ISSN: 2319-7064
Impact Factor 2025: 7.089

An Article of Survey Report on Mathematical Achievements and Applications During the Mughal Era

Sumaiya Ansari[1], Dr. Braham Pal Singh[2]

[1, 2]Department of Mathematics, J. V. Jain College, Saharanpur, U.P., 247001, India
Email: *ansari.sumaiya2021[at]gmail.com*

Abstract: ***Mathematics was used to build and organize the world during the Mughal Empire, not just as a topic for academics to debate. The Mughals were masters of "applied mathematics" despite not inventing any famous new formulas. They combined Islamic concepts, such as algebra and advanced geometry, with the best ideas from ancient India, such as zero and decimals. They were able to manage such a large empire thanks to this combination of knowledge. For example, they used geometry to ensure that each dome and tower was perfectly balanced and symmetrical when they built the Taj Mahal. Mathematics was also used in the "business side" of the empire. They devised a method to precisely determine how much grain or money a farmer should pay in taxes by measuring millions of acres of farmland with specific units and long ropes. They made sure that these skills were passed down from one generation to the next by opening schools and translating old science books into Persian. In a nutshell, the Mughals were the greatest "integrators" of mathematics, making it a useful tool for science, architecture, and money.***

Keywords: Mughal mathematics, applied geometry, land measurement and taxation, Taj Mahal design, Persian translation of science

1. Introduction

The Mughal Empire was a huge melting pot of cultures. In 1526, when the Mughals took power, they didn't just bring soldiers; they also brought a passion for education. They combined mathematical concepts from Persia and the Middle East with those from ancient India, such as Aryabhata's work. The Mughals put their efforts into making mathematics useful rather than searching for brand-new rules. They resembled the great "knowledge collectors" and "users." They used this combined mathematics for almost everything that made the empire run:

- **Building:** They used geometry to make the Taj Mahal's perfect shapes and balance.
- **Money and Taxes:** In order to determine fair taxes for farmers, they required mathematics to measure all of the country's land.
- **The Stars:** They used mathematics to track planets and create calendars for agricultural events and religious celebrations.
- **Trade:** Mathematics was used every day by traders to buy and sell goods over long distances. The Mughals ensured that these skills were not lost by supporting schools and translating old mathematics textbooks into Persian, the court's language. They functioned as a link between ancient customs and modern management techniques for a vast and successful empire.

2. Literature Review

According to historians, the Mughal empire was more of a "mathematics manager" than a "mathematics inventor" when it came to mathematics. Experts such as A Rahman makes the point that the Mughals didn't really spend a lot of time thinking of new recipes. Instead, they were great at preserving and putting old knowledge to use. Here is how the research breaks it down:

- **Running the Country:** Historian Irfan Habib explains that mathematics was a survival tool for the government. They used arithmetic and geometry to measure every inch of farmland and calculate crop averages. This wasn't just for fun- it was how they made sure they collected the right amount of taxes to keep the empire running.
- **Architecture:** Art historians like Ebba Koch look for "hidden mathematics" in famous monuments. The Taj Mahal made use of extremely sophisticated geometry and proportions, not just happened by accident. This shows that the builders were using high-level mathematics on the job site every day.
- **Mixing Cultures:** Academics like Roshdi Rashed demonstrate how the Mughals incorporated Indian practices into Islamic algebra. By translating Sanskrit books into Persian, they made sure that different types of mathematics experts could finally talk to each other and share ideas.

In short, most researchers agree that the Mughals' biggest achievement wasn't a new theorem. They were able to translate mathematics from various cultures, use it to build things, navigate the stars, and run a huge government. They were the ones who kept the flame of knowledge burning and made it useful for the real world.

3. Intellectual and Cultural Context

Intellectual and Cultural Context related points are such that

3.1. Patronage of Knowledge

The Mughal emperors- especially Akbar, Jahangir, and Shah Jahan—were huge fans of learning. They didn't just want power; they wanted to bring the best minds together. Akbar, in particular, transformed his court into a massive workshop where renowned Sanskrit mathematics and science books

were translated into Persian. There were a few simple reasons why this was significant:

- **Speaking the same language:** Since Persian was the language used for government and business, translating these books meant that officials could actually use the mathematics for their jobs.
- **Sharing ideas:** It enabled scholars trained in Islamic mathematics to finally read and comprehend the genius of ancient Indian mathematics by sharing ideas.
- **Better teamwork:** As a result of having people from different backgrounds converse with one another. They started combining their knowledge to solve problems together rather than working independently. The Mughals ensured that the best ideas from both cultures were preserved and used to run the country by doing this.

3.2. Educational Institutions

Madrasas (Islamic educational institutions) and traditional Hindu learning centers continued to teach arithmetic (hisab), algebra (al-jabr), geometry (handasa), and astronomy (ilm al-hay'a). Mathematics was often taught as part of practical sciences rather than as a purely theoretical discipline.

4. Major Areas of Mathematical Study

We have the following point related to areas mathematical study-

4.1. Arithmetic (Hisab)

Arithmetic formed the backbone of administration and commerce. Key areas included:

- Whole number operations
- Fractions
- Commercial arithmetic (profit, loss, interest, partnership)
- Measurement conversions
- Extraction of square and cube roots

India developed the decimal system we use today long before the Mughals did. The Mughals were capable of maintaining this system and putting it to extensive use. When it came to money, they were running such a massive empire that they couldn't just guess. Every official needed to know how to use numbers. They used decimal mathematics to count resources, keep track of taxes, and record everything the government owned in detail. The empire was able to stay organised and pay its bills thanks to everyday mathematics, not fancy theory.

4.2. Algebra (Bijaganita / Al-Jabr)

Algebra was like a "greatest hits" collection of mathematics during the Mughal era. They took the smart ideas from old Indian experts like Bhaskara II and mixed them with methods from famous Persian mathematicians. They studied, for instance, the following:

- **Simple equations:** Finding a missing number in a basic problem.
- **Complex equations:** Solving harder problems involving squared numbers.
- **Number Patterns:** Understanding how a list of numbers grows or changes is known as "number patterns."

Mughal scholars weren't trying to win awards for new inventions. Instead, they focused on translating old, difficult books and writing clear guides so that more people could understand them. They basically served as the mathematics world's teachers and librarians, making sure that these important skills were taught to everyone, from builders to government employees.

4.3. Geometry (Handasa)

Geometry was essentially a practical toolkit for the Mughals. They primarily used it for building large structures and tracking land.

- **Building domes and arches:** You can see huge, curved roofs on the Taj Mahal and the Red Fort. Architects needed to be extremely skilled at mathematics involving circles and arches in order to construct those without causing them to collapse.
- **Perfect Balance:** They couldn't get enough of things looking the same on both sides. Mathematics was used to ensure that their gardens and buildings were perfectly symmetrical. There had to be a fountain on the right at the same distance if there was one on the left.
- **Measuring Farms:** This was the "boring" part, but it was very important. Geometry was used by government workers to divide large, messy fields into simple triangles and rectangles. Because of this, figuring out how much land a farmer owned made it simple to assess them fairly.
- **Art and Tiles:** The star and flower patterns on their walls aren't just drawings. They are a series of repeating shapes that fit together perfectly, like a mathematics puzzle.

They didn't just sit around trying to come up with new mathematics rules. Instead, they took the rules that already existed and used them to build sturdy palaces and run a organized government

4.4. Trigonometry and Astronomy

Trigonometry was basically "sky mathematics" during the Mughal era.

- **Telling Time:** It was used to make a huge clock and map out of the sun and the stars. In order to accurately determine when to pray or when the sun would set, they measured the angles of the sun and stars because they did not have watches.
- **The Calendar:** They were able to predict the beginning of each month by keeping track of where the moon was. Festival and farming season dates were established in this manner.
- **Predicting Eclipses:** Their astronomers were able to precisely predict when an eclipse would occur using old Indian mathematics rules like sines and cosines so that people wouldn't be caught off guard.
- **Finding ways:** Using the stars, travelers avoided getting lost and found their way. By observing the height of particular stars in the night sky, mathematics assisted them in determining their location.

To keep up with the "mathematics charts" known as Zij, the emperors kept smart people on staff. There were a lot of numbers in these charts, which helped speed up these calculations. They didn't really invent new mathematics here;

they just became very good at using what already existed to keep the empire's schedule running on time.

5. Notable Scholars and Contributions

During this time, a few key people stood out for keeping mathematics alive and useful. They were not only "mathematics guys," but also frequently architects and historians.

- **Rashidi, Ataullah Ataullah-** was a famous scholar and builder from the 1600s. His biggest job was translating old, difficult mathematics books from Sanskrit into Persian. This was significant because it translated ancient Indian algebra into a language that all Mughal court officials and builders could understand. He served as a link between two distinct realms of knowledge.
- **Muhandis Lutfullah-** Mathematics and history were Lutfullah's strong points. He paid a lot of attention to how shapes function in the real world. He wrote specifically about geometry to assist with building projects. If you wanted to know the mathematics behind a sturdy wall or a perfect arch, he was the person who explained the technical side of how to actually construct them.
- **Ka Daivaja"-** Hindu scholars like Ka Daivaja were still very active, even though the government used Persian. He worked under Emperor Jahangir and wrote extensive commentaries (explanations) for classic Indian mathematics books. He ensured that the older Indian methods of mathematics were preserved and continued to be studied alongside the more recent Persian ones.

6. Applications of Mathematics in the Mughal Empire

On the basis of survey we have the following applications-

6.1. Revenue Administration

The Mughals used mathematics extensively in managing their money and land. This was in large part due to Todar Mal, Akbar's finance minister, who realised that the empire couldn't function on guesswork. He developed a mathematical method for collecting taxes. They carried it out as follows: Measuring Every Inch: Instead of just guessing how big a farm was, they used standardised ropes and rods to measure the exact area of the land. They turned messy, irregular fields into simple shapes to calculate the total size.

- **Averages:** They didn't just tax farmers based on one good year; they did it all the time. The average was determined after they examined crop yields for ten years. This was a very early form of statistics used to make sure the taxes were fair.
- **Standard Units:** They created official units of measurement so that an acre in one city was the same as an acre in another. This prevented local officials from defrauding the king or farmers.
- **Dividending the Harvest:** They used fractions to precisely determine how much went to the farmer and how much to the state. This use of "daily mathematics" was a game changer. It made the empire's economy much stronger because the government knew exactly how much money was coming in, and farmers knew exactly what they owed. Mathematics was used to ensure stability and fairness.

6.2 Architecture and Urban Planning

In Mughal architecture and city planning, mathematics was the secret ingredient that made everything work. They didn't just build by eye; they used precise geometry to make sure their massive structures were both beautiful and safe. The following is how they apply mathematics: Holding up Domes: To build those huge, heavy marble domes, they had to calculate "load distribution." This meant using mathematics to figure out how to spread the weight down through the arches so the roof wouldn't collapse.

- **Perfect Symmetry:** The Mughals were big on balance. If you cut a building like the Taj Mahal in half, the left side is a perfect mirror of the right. They made sure that every window and pillar was exactly where it should be by using ratios. The Garden Layout (Charbagh): Their gardens weren't just random patches of grass. They used "quadrilateral division," which means they used geometry to split the land into four equal squares with water channels in the middle. This was meant to look like paradise.
- **Water Flow:** They even used mathematics for their fountains and streams. They had to calculate the "gradient" (the slope of the ground) so that water would keep moving at a steady pace through the gardens without needing pumps.

In essence, their buildings resembled enormous mathematics puzzles. Before the first brick was laid, numbers were used to plan out each arch and garden path.

6.3 Engineering and Irrigation

Engineering was all about moving water and building strong defences for the Mughals. They solved a lot of everyday problems on a large-scale using mathematics. Here's how they put it to use;

- **Moving Water:** To build long canals, they had to calculate the "slope" of the land perfectly. If the ground was too flat, the water would just sit there and get gross; if it was too steep, it would move too fast and wash away the banks. They used mathematics to determine the ideal angle to maintain water flow to farms and cities.
- **Water Machines:** They lifted water from deep wells with tools like the "Persian Wheel." To construct these, one needed to be familiar with gears and circles so that the wooden teeth could fit together and lift water effectively.
- **Strong Forts:** When building massive walls for places like the Agra Fort, they used geometry to design "bastions" (the round towers on the corners). These were angled precisely so that soldiers could see in all directions and enemies could not hide in them. They used mathematics to design arches that could support the weight of elephants and carts while allowing the river to flow underneath in order to construct bridges that could withstand heavy monsoon rains. The fundamental concern of their engineers' mathematicians was "how do we make this work?" rather than merely asking, "How can we make this look nice?" Making the empire's infrastructure durable and dependable was everything.

6.4 Commerce and Trade

India was the hub of global trade at the time. To survive the workday, you needed to be a "mathematics whiz" if you wanted to be a businessman. In the markets, they used mathematics as follows:

- **Swapping Money:** People came from all over the world to trade. The value of a Persian gold coin versus a Mughal silver coin had to be determined quickly by merchants.
- **Checking Weights:** Everything was sold by weight, whether it was pepper or silk. Merchants used mathematics to calculate prices based on exactly how heavy the goods were, using official scales to keep things fair.
- **Sharing the Pot:** The majority of significant business trips were collaborative endeavors. They used simple division to ensure that each partner got their fair share of the profit based on what they invested when the money came in.
- **Navigating ships:** The stars were used by sailors to navigate their ships across the ocean. To ensure that their cargo actually reached the appropriate port, they calculated their position using "star mathematics." Mathematics was, in essence, the market's beating heart. Trade would have degenerated into a jumble of disagreements and errors without it.

7. Mathematical Instruments

To get their mathematics right, the Mughals used some "old-school" gadgets. These were basically the high-tech tools of the day.

- **Astrolabes:** These were like a handheld GPS and a clock in one. By looking at the stars through it, you could figure out exactly where you were or what time it was.
- **Sky Globes:** These were big metal balls with stars carved on them. Astronomers used them as a 3D map to see how the sky changed throughout the year.
- **Quadrants:** These were shaped like a slice of pizza. You'd point one end at the sun or a star to measure its height, which was the main way they navigated on long trips.
- **Sundials:** These were the most common. They used the sun's shadow to tell the time of day, and some were built as huge stone structures in palace gardens.

You had to be really good at geometry just to use these things. They were the reason the Mughals could make accurate calendars and sail ships across the ocean without getting lost.

8. Limitations and Historical Evaluation

On the basis of survey limitations and historical evaluation are such that-

- It's important to be honest when looking back: when it came to mathematics, the Mughals didn't create anything new. Like earlier Indian geniuses, they did not come up with ideas that changed the world. They did not, for instance, match the "big leaps" of guys like: Aryabhata, who came up with a very precise value for Brahmagupta, who basically established the guidelines for using zero. The Kerala School, which experimented with concepts prior to Europe's development of calculus. So, what's the point of Mughal mathematics? They were excellent translators and managers, which was their strength. Instead of inventing new mathematics, they:
- They preserved knowledge by translating old books to prevent their loss.
- **Paid the bills:** The emperors gave money to scholars and built schools, which kept mathematics as a respected career.
- **Put it to use:** They took "classroom mathematics" and applied it to the management of fair taxes, the construction of incredible structures, and the administration of a large government.
- **Mixed cultures:** They amalgamated the best ideas from Hindu and Islamic traditions. In other words, they were just trying to be the best at using mathematics to run a country rather than trying to be the greatest mathematicians in history.

9. Long-Term Influence

The Mughals weren't trying to be mathematical wizards, to put it simply. They simply excelled at completing tasks by utilising mathematics. This is the deal: They translated old Indian mathematics books to keep them from being lost, saving the good stuff. They reminded me of mathematics librarians. The Big Mix: They combined the most innovative concepts from India and the Middle East. Work in the real world: They were uninterested in fancy theories. They used mathematics to build the Taj Mahal, measure farmland, and make sure taxes were fair.

The Hand-Off: Despite the fall of the empire, people continued to utilise their systems for hundreds of years. In essence, they were the best players of the game, not the ones who invented it. They made athematics practical for everyday use.

10. Conclusion

The Mughal era represents a critical phase in the history of mathematics in India—not as a period of radical theoretical innovation, but as an era of synthesis, preservation, translation, and application. Mathematics became a practical science deeply embedded in governance, architecture, astronomy, engineering, and commerce. The Mughal rulers ' patronage enabled intellectual exchange between Persian and Indian traditions, ensuring that mathematical knowledge remained active and relevant in both scholarly and administrative contexts.

Thus, the mathematical achievements of the Mughal period lie not only in texts and scholars but in the very structures, cities, and systems that continue to stand as monuments to mathematical precision.

References

[1] Below is a properly formatted reference list (APA style; can be converted to MLA/Chicago if needed):
[2] Asher, C. B. (1992). *Architecture of Mughal India*. Cambridge University Press.
[3] Habib, I. (1999). *The Agrarian System of Mughal India (1556–1707)* (2nd ed.). Oxford University Press.

[4] Koch, E. (2006). *The Complete Taj Mahal and the Riverfront Gardens of Agra*. Thames & Hudson.
[5] Rahman, A. (1982). *Science and Technology in Medieval India*. Indian National Science Academy.
[6] Rashed, R. (1994). *The Development of Arabic Mathematics: Between Arithmetic and Algebra*. Kluwer Academic Publishers.
[7] Saliba, G. (2007). *Islamic Science and the Making of the European Renaissance*. MIT Press.
[8] Sarma, K. V. (1972). *A History of the Kerala School of Hindu Astronomy*. Vishveshvaranand Institute.
[9] Pingree, D. (1970). "Astronomy and Astrology in India and Iran." *Isis*, 61(2), 229–246.
[10] King, D. A. (1999). *World-Maps for Finding the Direction and Distance to Mecca*. Brill.