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An Analysis of Cross-Cultural Influences on The Development of Modern Mathematics

KEYWORDS: abstraction, renaissance, precision, transmission, history

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ABSTRACT *Present day Mathematics as it is understood and studied got its formal design only during the nineteenth and twentieth centuries in the Western World, but then as it is known, no knowledge develops in vacuum. The history of Mathematics is the history of mathematical interests and inventions in the Asian countries and finally taking the formal shape in the Western World. Not to say then, there has been strong role of cross cultural influences on the Development of Mathematics, which has been throughout neglected in the Western World and is propagated as if all the Mathematical Concepts have found their development in the Western World only. There appears to be gross non acceptance of contribution of the countries and regions outside the western world. This fallacy is now being corrected by the Mathematicians both in the Western World as also in the non-Western World.*

It is India that gave us the ingenious method of expressing all numbers by means of ten symbols, each symbol receiving a value of position, as well as an absolute value; a profound and important idea which appears so simple to us now that we ignore its true merit, but its very simplicity, the great ease which it has lent to all computations puts our arithmetic in the first rank of useful inventions; and we shall appreciate the grandeur of this achievement when we remember that it escaped the genius of Archimedes and Apollonius, two of the greatest men produced by antiquity. - Pierre-Simon Laplace (Nehru, J.L.,1946)

Mathematics represents a high level of abstraction attained by the human mind. In India, Mathematics has its roots in Vedic literature which is nearly 4000 years old. Between 1000 B.C. and 1000 A.D. various treatises on Mathematics were authored by Indian mathematicians in which were set forth for the first time, the concept of zero, the techniques of Algebra and algorithm, square root and cube root. This method of graduated calculation was documented in the Pancha-Siddhantika (Five Principles) in the 5th Century. But the technique is said to be dating from Vedic times circa 2000 B.C. (Gupta, A.P., 2011)

While there was an awareness of ancient Indian mathematics in the West since the sixteenth century, historians discuss the Indian mathematical tradition only after the publication of the first translations by Colebrooke in 1817. Its reception cannot be comprehended without accounting for the way new European mathematics was shaped by Renaissance humanist writings. (Heeffer, A, 2007)

The earliest traces of mathematical knowledge in the Indian subcontinent appear with the Indus Valley Civilization (c. 4th millennium BC ~ c. 3rd millennium BC). They designed a ruler—the Mohenjo-daro ruler—whose unit of length (approximately 1.32 inches or 3.4 centimetres) was divided into ten equal parts. This shows that the maths was quite advanced even at that time but later on the inventions of some mathematicians revolutionized the world. (Anandamela, 2013)

The people of the Indus Valley Civilisation demonstrated the use of mathematics in their daily life such as:

They manufactured bricks with dimensions in the proportion 4:2:1 to lend stability of a brick structure.

They used a standardized system of weights based on the ratios: 1/16, 1/8, 1/4, 1/2, 1, 2, 4, 10, 20, 40, 100, 200, 400, 500 and 800, with the unit weight being approximately 13.63 grams. The heaviest known weight was about 10.9 Kg and the lightest 85.1 centigrams.

The weights were made in regular geometrical shapes like hexahedra, barrels, cones, and cylinders, thereby demonstrating knowledge of basic geometry.

The Sathpatha Brahmana, in around 900 BC, records the theorem of Pythagoras 400 years before Pythagoras. It is a recorded fact that Pythagoras who lived around 500 BC visited India and interacted with Indian Mathematicians and scholars. In fact Indian tradition records that he turned vegetarian under the influence of Jainism after visiting India. Pingal discovered the Meru Prastara in 200 BC which is now known as Pascal's Triangle, discovered by Pascal 1800 years after Pingal. He wrote this in his book the Chandah Sutra. Halayudh wrote a commentary on Pingal's work and in the process discovered the Binomial Theorem 400 years before Newton. There is evidence that the Jain mathematicians understood different orders of infinity thereby anticipating in many ways the great discoveries of Georg Cantor. (Singh, D., 2010)

Contrary to the false history that the calculus originated with Newton and Leibniz, it has now been firmly established that the calculus originated in India. The process started in the 5th c., with Aryabhata's attempts to calculate precise trigonometric values. That precision was needed for practical reasons for accurate astronomical models, and the calendar—essential for monsoon dependent agriculture—as also for navigation. (Raju, C.K., 2011)

The history of the transmission of the calculus makes clear this clash of philosophies, or math war as I have called it. In the 16th c. CE, Jesuits based in Cochin, stole the calculus from India. The reason for the theft was the great practical value of the calculus. This practical value arose since the calculus was used by Indians to derive precise trigo-

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nometric values (precise to the 9th decimal place). Those trigonometric values were badly needed in the 16th c. to solve the problems of (and specific to) European navigation. (Raju, C.K., 2011)

Before the middle of the seventh century CE, after Buddhism had become rooted in China, Indian astronomers worked in the Chinese capital. They were more reliable for predicting solar eclipses than those current in China. The political significance of solar eclipses led the Chinese court from the turn of the eighth century to depend on resident foreign astronomers. (China Institute, 2010)

Indian Mathematics emerged in the Indian subcontinent from 1200 BC, until the end of the 18th century. The decimal number system in use today was first recorded in Indian Mathematics. Indian mathematicians made early contributions to the study of the concept of zero as a number, negative numbers, Arithmetic, and Algebra. In addition, Trigonometry was further advanced in India, and, in particular, the modern definitions of sine and cosine were developed there. These mathematical concepts were transmitted to the Middle East, China, and Europe and led to further developments that now form the foundations of many areas of Mathematics. (Datalogi, 2011)

Our modern system of positional decimal notation with zero, together with efficient algorithms for computation, which were discovered in India some time prior to 500 CE, certainly must rank among the most significant achievements of all time. (Bailey D.H. & Borwein, J.M., 2011)

Early Hindu mathematics was produced by a very much different type of people. India's work in science is at once old and new. Young as a secular pursuit and old as the core of Hindu life was religion. It was to religion that mathematics was the servant. (Such was also the case in the West, as during the Medieval period the art of computation was taught particularly for the calculation the date of Easter.) Astronomy grew from the worship of the stars, and their observation was put to the service of feast day, planting and other necessities of life. In this respect mathematics in India was similar to that of Egypt. And as in the Middle Ages of the western world, the scientists of India were her priests. (Allen, D., 2002)

The geographical location of India made it throughout history an important meeting place of nations and cultures. This enabled India from the very beginning to play an important role in the transmission and diffusion of ideas. The traffic was often two-way, with Indian ideas and achievements traveling abroad as easily as those from outside entered. Archaeological evidence shows both cultural and commercial contacts between Mesopotamia and the Indus Valley. While there is no direct evidence of mathematical exchange between the two cultural areas, certain astronomical calculations of the longest and shortest day included in the Vedanga Jyotisa, the oldest extant Indian astronomical / astrological text, as well as the list of twenty - eight nakshatras found in the early Vedic texts, have close parallels with those used in Mesopotamia. (Joseph G.G., 2010)

Due to the location of India, in comparison to European countries, Indian mathematics almost always traveled to European countries through Arabic mathematicians. These Arabic mathematicians learned of astronomy, among other ideas as well, and took the Hindu trigonometry and expanded upon it. It is through this translation of ideas, that many of our mathematical terms are derived. Hindu mathematicians were the first to create many of the numbers and formulas we use today. It was their number system that allows us to do simple math efficiently and effectively, instead of the minute system used in the Roman Empire. The Hindus were advanced in their geometry, which enabled them to build elaborate temples and cities. There is also evidence of numbers and their place value system in the Vedas. This enabled the Brahmins (priestly class) to learn and explore mathematics. However, it was not only the Brahmins that were able to engage in mathematics, but also the Kshatriyas who took care of war and government matters. This led to the practical uses of mathematics for temple building, geometry, and most importantly astronomy and helped to pave the way for future generations. (Carlson, K., 2010)

In the past many western scholars thought that Indians had not done any original work till the time of Bhaskara II but this is indeed far from the truth. In fact, the growth of Indian mathematics did not stop with Bhaskara II either as will be noted that some aspects of Indian mathematicians may have been rediscovered by Europeans later – the development of number theory, the theory of indeterminates, infinite series expressions for sine, cosine and tangent, computational mathematics. (Tularam, G.A., 2010)

One area of study of the history of mathematical methods in Greek astronomy that has received some careful consideration is the study, via Sanskrit texts found largely in India, of the history of methods in astronomy predating those of Ptolemy. I must mention Census of the Exact Sciences in Sanskrit, a series of volumes that will doubtless open up to researchers in many areas paths that lead to real treasures. (Berggren, J.L., 1984)

It is true that "Aristotelian" logic, is not very different from Nyaya logic—as is to be expected since Nyaya works found their way probably into Jundishapur, if not Alexandria, and certainly into Baghdad, and thence into Arabic books that were all subsequently attributed wholesale to Aristotle at Toledo. (Raju, C.K., 2006)

Since the center of the Islamic world was, and still is, between Europe and the Indian subcontinent, it is not surprising that Arabic mathematics was heavily influenced by both Greek and Indian mathematics. Two absolutely crucial legacies of Arabic mathematics are the following:

(1) It preserved a very substantial amount of classical Greek mathematics that would otherwise have been lost or ignored.

(2) It also passed along the important new insights that Indian mathematicians had discovered. (Burton, D.M., 1997)

Europe got its early arithmetic and algebra from the Arabs—hence the 'Arabic numerals'—but the Arabs themselves had previously taken them from India. The astonishing progress that the Indians had made in mathematics is now well known and it is recognized that the foundations of modern arithmetic and algebra were laid long ago in India. (Nehru, J.L.,1946)

It appears even to a casual observer that India has good reasons to be proud of its heritage in Mathematics. It can even be said that the sustained efforts in India led, through the Arabs, to the revival of mathematics in Europe. Scholars have noted that the decimal system was

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already in place in the Harappan period, though a few centuries had to lapse for its importance to be appreciated fully. Arithmetic operations and sequences, fractions and certain geometric rules were known some one thousand years before Christ, including results such as the Pythagoras theorem. Jains were fascinated by large numbers and had an advanced knowledge of infinity (though it fell far short of our present understanding), and maintained the tradition of mathematics for centuries. Buddhists knew infinite and indeterminate numbers. Important developments came through astronomy. (Sreenivasan, K. R., 2007)

Buddhism was the medium for cultural exchange between India and China, providing opportunities for the exchange of ideas. Buddhism exerted great influence in various fields in China and was the main vehicle for transmission of Indian scientific ideas to that land. The influence was so great that even scientists embraced the new faith. For instance, the astronomer Han Chai and the mathematician Wang Fan both became Buddhists. A great deal of Indian astronomy and mathematics became known in China through the translation of Indian works, and through the visits of Indian scholars. (Gupta, R.C., 1989)

The fact that the numeral system common today—the closest we have to a universal language—comes from India is well known. The idea of zero and its integration into the place-value system, which enabled one to write numbers no matter how large using only ten symbols, originated in India. At first encounter, it appeared marvelous to West Asians, and "satanic" to Christian clerics in the Europe of the Middle Ages. After quick adoption in ninth-century Baghdad, it came slowly to be transmitted to Christian Europe around the thirteenth century through Jewish scholars working in Islamic Spain. This long and tortuous path is illustrated by the works of such distinguished scholars as the Persian mathematician al-Khwarizmi (783-850), who worked in the House of Wisdom at Baghdad and from whose name the word algorithm is derived, and Fibonacci of Pisa (1170-1250), famous for the Fibonacci sequence still familiar today. (Narasimha, R., 2009)

Study of development of the number system in India cuts across the Vedic, Jaina and Buddhist traditions. From the early times one sees a fascination for large numbers in India, as we noted in the earlier sections on the Vedic and Jaina traditions. Large numbers are also found in the Buddhist tradition, and Buddha himself was renowned for his prowess with numbers. (Dani, S.G., 2008)

India has had a long tradition of more than 3000 years of pursuit of Mathematical ideas, starting from the Vedic age. The Sulvasutras (which included Pythagoras theorem before Pythagoras), the Jain works, the base 10 representation (along with the use of 0), names given to powers of 10 up to 10^{53}, the works of medieval mathematicians motivated by astronomical studies, and finally the contributions of the Kerala school that came strikingly close to modern mathematics, represent the various levels of intellectual attainment. There is now increasing awareness around the world that as one of the ancient cultures, India has contributed substantially to the global scientific development in many spheres, and mathematics has been one of the recognized areas in this respect. The country has witnessed steady mathematical developments over most part of the last 3,000 years, throwing up many interesting mathematical ideas well ahead of their appearance elsewhere in the world. (Dani, S.G., 2012)

Indian knowledge of planetary dynamics and higher mathematics including calculus was fairly advanced, prior to the beginning of the European renaissance period in the 14-15th century AD. After the decline of Greek and Roman Empires by 4th cent AD the centre of scientific, activity at the global level became India where the socio-political situations were stable and favorable for new knowledge creation in diversified fields. Studies in planetary dynamics in both physical and mathematical perspective by Indian astronomers in the context of astronomy as well as astrology can be considered to be important in the history sciences during the European dark ages. There are independent evidences which suggest that Arab astronomers during the medieval period (11th to 15th cent AD) were aware of Indian contributions planetary physical forces. There is every possibility that the new knowledge created in India in areas like astrophysics and differential calculus was made available to the European scientists during renaissance period directly or indirectly through Arab and Christian missionary routes of transmission. (Girish, T.E. & Nair, C.R., 2011)

The importance of the creation of the zero can never be exaggerated nor can it be attributed merely to luck, because, as Prof Halstead put it, 'This giving to airy nothing, not merely a local habituation and a name, a picture, a symbol but helpful power, is the characteristic of the Hindu race from whence it sprang. No single mathematical creation has been more potent for the general facilitation of mathematical intelligence and power. The Greeks and Romans had symbols like ' X' ,Multiplying a symbol 'X' by another symbol 'X' is almost inconceivable without assigning the specific properties of the numerical symbols from 1 to 9.They had to use a clumsy device called the Abacus which consisted of beads on wires in a frame. Zero has been in regular use ever since the 5th century by Aryabhatta. (Sarathi, V.P., 2009)

The scientific cooperation between India and the Arabs dates back to the time of Abbasid Caliphate of Baghdad when a number of books on astronomy, mathematics, and medicine were translated from Sanskrit into Arabic. From then on, the ancient scientific knowledge of India continued to influence Muslim scientists. Arab interest in Hindu sciences was parallel to their interest in Greek learning. The Greek and Sanskrit texts on mathematics and astronomy were used by Muslim scientists as bedrock to develop new fields. Hindu mathematics left a more lasting impression on the Arab sciences. What we call today Arabic numerals, were in fact Indian numbers. The Arabic word for numbers is Hindsah, which means from India. (Virk, Z., 2011)

The European Scholars who postulated the Aryan invasion theory were biased, unscientific—and ultimately wrong. The Rig Veda was cognized by a people indigenous to India, probably sometime long before 3,000 BC. So we move on to the next question. How did the Vedic Civilization of India influence the civilizations of the Middle-East, Egypt, and Europe? Evidence from a variety of sources show that an influence of Vedic civilization flowed west to the continent of Europe. As we see, science and mathematics originated in India and came to Greece centuries later. Science and mathematics were probably introduced into Europe and Egypt from India, possibly through Persia, Arabia, and Mesopotamia, although possibly also directly. (Chandler, K., 2008)

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CONCLUSION

Without doubt, the present day Mathematics as it is understood and studied got its formal design only during the nineteenth and twentieth centuries in the Western World, but then as it is known, no knowledge develops in vacuum. There has to be some

background work and basic knowledge on the basis of which new knowledge develops and makes the discipline easy to understand and to comprehend. Mathematics is no different. The history of Mathematics is the history of mathematical interests and inventions in the Asian countries and finally taking the formal shape in the Western World. Not to say then, there has been strong role of cross cultural influences on the Development of Mathematics, which has been throughout neglected in the Western World and is propagated as if all the Mathematical Concepts have found their development in the Western World only. There appears to be gross non acceptance of contribution of the countries and regions outside the western world. This fallacy is now being corrected by the Mathematicians both in the Western World as also in the non-Western World.

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