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A Review on Indian Decimal Place Value System-Greatest Indian Contribution to the Development of Mathematics

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Abstract

In this paper, Indian decimal place value system have been discussed which is undoubtedly one of the greatest Indian contributions to the development of mathematics, and its wider applications in all other disciplines. Further I have discussed why this discovery is one of the greatest discoveries and phenomenal development in the decimal place value system has been explained. From the earliest numerate civilization of the Indus valley, Indian scholars led the world in the field of mathematics. Indian scholars created and refined the current decimal place value system of numeration, including the number zero, without which higher mathematics would not be possible. Our modern system of positional decimal notation with zero, together with the basic arithmetic computational schemes, was discovered in India prior to 500 CE. But the work of Indian mathematicians has been severely neglected by western and Eurocentric historians.

Introduction

The decimal place value system is a method of representing or encoding numbers. Positional notation is distinguished from other notations (such as Roman numerals) for its use of the same symbol for the different orders of magnitude (for example, the "ones place", "tens place", "hundreds place"). This greatly simplified arithmetic led to the quick spread of the notation across the world.

Aryabhata stated "*sthānam sthānam daśa guṇam*" meaning "From place to place, ten times in value". Indian mathematicians and astronomers also developed Sanskrit positional number words to describe astronomical facts or algorithms using poetic sutras.

The decimal Place value is very interesting to think about. Believe it or not, place value is a relatively new notion in mathematics. It took humans 28,000 years to come

up with the notion of present place value. It was by 500 A.D., when Indians had invented a base 10 system that had unique symbols for the numbers 1 through 9, employed a place value notation, and used a zero. This is the system that evolved into the way we express numbers today. In India, the concepts of 0 as a placeholder and 0 as a number were associated with one another much earlier than in Babylon. It is from the Indians that we get our present-day symbol for 0.

Georges Ifrah concludes in his *Universal History of Numbers*:

Thus it would seem highly probable under the circumstances that the discovery of zero and the place-value system were inventions unique to the Indian civilization. As the Brahmi notation of the first nine whole numbers (incontestably the graphical origin of our present-day numerals and of all the decimal numeral systems in use in India, Southeast and Central Asia and the Near East) was autochthonous and free of any outside influence, there can be no doubt that our decimal place-value system was born in India and was the product of Indian civilization alone.

Why this discovery greatest?

The one reason this discovery gets so little attention today is that it is very hard for us to appreciate the enormous difficulty of using Greco-Roman numerals, counting tables and abacuses. As Tobias Dantzig (father of George Dantzig, the inventor of linear programming) wrote, Computations which a child can now perform required then the services of a specialist, and what is now only a matter of a few minutes [by hand] meant in the twelfth century days of elaborate work.

Its significance is best stated by French mathematician, Laplace: “ The ingenious method of expressing every possible number using a set of ten symbols (each symbol having a place and absolute value emerged in India. The idea seems so simple nowadays that its significance and profound importance is no longer appreciated.

As Laplace noted, the scheme is anything but “trivial," since it eluded the best minds of the ancient world, even superhuman geniuses such as Archimedes. Archimedes saw far beyond the mathematics of his time, even anticipating numerous key ideas of modern calculus and numerical analysis. He was also very skilled in applying mathematical principles to engineering and astronomy. Nonetheless he used a cumbersome Greek numeral system for calculations. Archimedes' computation of pi, a tour de force of numerical interval analysis, was performed without either positional notation or trigonometry.

Today we take our decimal system for granted as the 19th century mathematician Pierre-Simon Laplace explained:

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 and the great ease which it has lent to all computations put our arithmetic in the first rank of useful inventions; and we shall appreciate the grandeur of this achievement the more when we remember that it escaped the genius of Archimedes and Apollonius, two of the greatest men produced by antiquity.

G Halstead commented to do justice to its importance :
The importance of the creation of the zero mark can never be exaggerated. 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 on go of intelligence and power.

Phenomenal development of the decimal place value system

A lot of attempts have been made to attribute the first use of a place value system to the ancient Babylonian civilization of Mesopotamia. While it cannot be denied that the Babylonians used a place value system, the notion of place value was first conceived by the Babylonians somewhere between 2000 B.C.E. and 1000 B.C.E. Their place value system was different from the one we use today because it was base 60 rather than base 10. Anyway, this Babylonian system was all very fine except initially it lacked a symbol for zero. While the concept of place value may have come from Mesopotamia, the Indians were the first to use it with a decimal base (base 10). There is now very little doubt among historians that this invention originated from the Indian subcontinent. That said, it was considered, until recently, that Arabic scholars were responsible for the system, as C Srinivasiengar writes:
...During the earlier decades of this century (20^{th}) attempts were made to credit this invention wholly or in part to the Arabs.

All current evidence shows that the Indian system having been influenced by the base 10 Chinese 'counting boards' and the place value system of the Babylonians but combined use of decimal numerals and place value first occurred on the Indian subcontinent. Undoubtly, the use of a decimal system was based on counting with our ten fingers but the key contribution of the Indians is not in the development of nine symbols to represent the numbers one to nine, but the invention of the place holder *zero*. Eurocentric scholars assumed the symbol for zero was a Greek invention, with no proof at all. The claims were based of pure speculations that zero came from the Greek letter omicron (O), the first letter of the Greek word *ouden* meaning empty. We know this to be untrue, but it serves as a timely reminder of the struggle for recognition of Indian mathematical developments.

But there is significant evidence that an early system was in use by the inhabitants of the Indus valley by 3000 BC. Excavations at both Harappa and Mohenjo Daro have supported this theory. In India a decimal system was already in place during the Harappan period, as indicated by an analysis of Harappan weights and measures. Weights corresponding to ratios 0.5,1,2,10,20,50,100,200, and 500 have been identified as have scales with decimal divisions. A bronze rod marked in units of 0.367 inches points to the degree of precision demanded in those period. At this time however a 'complete' place value system had not yet been .The formation of the numeral forms as we know them now has taken several thousand years, and for quite some time in India there were several different forms. These included Kharosthi and Brahmi numerals, the latter were refined into the Gwalior numerals, which are notably

similar to those in use today. Study of the Brahmi numerals has also lent weight to claims that decimal numeration was in use by the Indus civilisation as correlations have been noted between the Indus and Brahmi scripts. 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 powess with numbers; Tallakshana , a term from the Buddhist tradition, represented 10^{53}. The names of powers of 10 however differed over traditions and also over period; e.g. Parardha, which literally means “halfway to heaven", meant 10^{12} in early literature, it stood for 10^{17} in later works such as of Bhaskara II. The oral tradition of usage of several powers of 10 is likely to have played a crucial role in the emergence of decimal representation in written form at later stage, apparently in the early centuries of the common era. This connection is however not very straightforward; there was a long period, of several hundred years, in between when written form of numbers did not follow the place value notation; besides, even after the decimal place value system with zero came into vogue the other systems seem to have continued to be used for quite a while. One may wonder about the reasons for this in the context of the frequent references to the powers of 10 in the oral tradition, and the apparent convenience and elegance of the decimal place value system. On the other hand the Chinese seem to have used decimal place value system for representation of numbers, without a symbol for zero in place of which they left a blank space, from very early times and at least from the 3rd century BCE.

The inventor of the zero symbol is unknown, but what is known is that it was firstly denoted by a dot, then possibly a circle with a dot in the centre, and later by the oval shape we now use. Prior to its invention, Indian mathematicians had already taken to leaving an empty column on their counting boards and clearly at some point this empty space was filled. The Indians referred to zero as 'sunya' meaning void. Evidence can be found in the work of the famous Indian grammarian Panini (5^{th} or 6^{th} century BC) and later the work of Pingala a scholar who wrote a work, *Chhandas-Sutra*. The first documented evidence of the use of zero for mathematical purposes is not until around 2^{nd} century AD (in the Bakhshali manuscript). The first recorded 'non-mathematical' use of zero dates even later, around 680 AD, the number 605 was found on a Khmer inscription in Cambodia. Despite this it seems certain that a symbol was in use prior to that time.

Introduction of zero as a place holder paved the way for the writing the numbers as we do now, as far as the whole numbers are concerned; the full decimal representation system as we now use, extending also to the fractional part, with a separating decimal point, had its beginnings in the 15th century Europe, though it is noted to have been first used by Arabs in the 10th century.

Having become firmly established in academic circles in India by the 6^{th} century, the decimal place value system spread across the world. Initially to China and Alexandria, then to the Arab empire where it became the system of choice of the scholars in Baghdad by the 8^{th} century.

Arabic scholars during this time improved the system by introducing decimal fractions. The system also spread into Spain, as has been previously discussed southern Spain was under Arabic rule into the 12th century. It took much longer for the system to be accepted in mainland Europe, but eventually by the 16th century it was widely used. This is a brief overview of the phenomenal development of the decimal place value system, without which it is accepted 'higher mathematics' would not be possible.

Conclusion

The greatest development of modern mathematics is place value system of enumeration, the base ten system of calculation ranging from minutest decimal to the most inconceivably large power of ten. This system was neither developed by Greeks nor by the Arabs, despite the fact that this numeral system is commonly called the Arabic numerals in Europe. Rather this system was invented in India, where it evidently was of quite ancient origin.The earliest extant inscriptions involving the decimal numeral system is said to be from Gujarat, dated 595 CE; it has however been argued by R.Saloman that this is a spurious inscription. The oldest known zero in an inscription in India is from 876 CE and is found in a temple in Gwalior (an image of this may be viewed online). In any event, we entirely agree with Dantzig, Ifrah and others that the discovery of positional decimal arithmetic, by an unknown scholar in early first millennium India, is a mathematical development of the first magnitude. The fact that the system is now taught and mastered in grade schools worldwide, and is implemented (in binary) in every computer chip ever manufactured, should not detract from its historical significance. Perhaps someday we will finally learn the identity of this mysterious Indian mathematician.

References and Books:

[1] Boyer, C. B. (1968). *A History of Mathematics.* USA: John Wiley and Sons, INC.
[2] Al-Daffa, A. A. (1977). *The Muslim Contribution to Mathematics.* USA: Humanities Press.
[3] Datta, B. and Singh, A. N. (1962). *History of Hindu Mathematics, a source book*, Parts 1 and 2, (single volume). Bombay: Asia Publishing House.
[4] Duncan, D. E. (1998). *The Calendar*. London: Fourth Estate.
[5] Gurjar, L. V. (1947). *Ancient Indian Mathematics and Vedha*. Poona
[6] Joseph, G. G. (2000). *The Crest of the Peacock, non-European roots of Mathematics*.
[7] Princeton and Oxford: Princeton University Press.
[8] Katz, V. J. (1998). *A History of Mathematics* (*an introduction*). USA: Addison-Wesley.
[9] Rashed, R. (1994). *The Development of Arabic Mathematics: between Arithmetic and Algebra*

[10] Srinivasiengar, C. N. (1967). *The History of Ancient Indian Mathematics.* Calcutta: The World Press Private LTD.
[11] Struik, D. J. (1948). *A Concise History of Mathematics.* New York: Dover Publications, INC
[12] George Ifrah, Universal History of Numbers, Translated from the 1994 French original by David Bellos, E. F. Harding, Sophie Wood and Ian Monk. John Wiley & Sons, Inc., New York, 2000.
[13] R. Salomon, Indian Epigraphy, A Guide to the Study of Inscriptions in Sanskrit, Prakrit, and the Other Indo-Aryan Languages, Oxford University Press, 1999.
[14] L. Berggren, J. M. Borwein and P. B. Borwein, Pi: a Source Book, Springer-Verlag, New York, third edition, 2004.
[15] Reviel Netz and William Noel, The Archimedes Codex, Da Capo Press, 2007.
[16] Will Durant, Our Oriental Heritage, vol. 1 of The Story of Civilization, 11 vols., Simon and Schuster, New York, 1954 (date of vol. 1).