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LILAVATI: REIMAGINING WOMEN'S CONTRIBUTION IN ANCIENT INDIAN MATHEMATICS

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Abstract

India has been the land of great discoveries since ancient times in the field of science and technology. Since the Vedic period India has seen the rise of exceptional women who navigated the realms of arithmetic, algebra, geometry, that contributed to the Indian knowledge system. The scholars like Gargi, Lopamudra, and Maitreyi resonate, their mathematical insights illuminating the ancient texts with profound understanding. In the 12th century, Lilavati, an illustrious mathematician from ancient India, left an incredible mark in the history of mathematics which was always a man dominated area. She is credited with developing new methods of solving complex mathematical problems. The Bhaskarachaya, father of Lilavati dedicated his work Lilavati to his daughter which mainly covers a wide array of topics, including arithmetic, algebra, geometry, and equations. This paper seeks to shed light on the life and work of Lilavati, an extraordinary woman whose contributions continue to resonate in the realms of mathematics.

INTRODUCTION

Bhaskaracharya (1114-1185) a great Indian mathematician was born in 1114 at Bijjal Bid close to western ghat in India. Bhaskaracharya, meaning Bhaskar the teacher displays many useful pedagogical qualities through his writings. He was considered as outstanding peot-mathematician during his times. He was a prolific writer and wrote profusely in mathematics and astronomy. Learning mathematics at that time was restricted to the family -based system from father to son who pursued it. The role of women in mathematics during those times was negligible it was highly restricted. Even religion also played a key role in formulation of mathematical beliefs and any form of challenges to religion was not allowed.

Bhaskaracharya was a contemporary to Bramha Gupta, another scholar of mathematics at the ujjain belonged to Ashmak School whose main concern was to reinterpret the works of Aryabhatta . Bhaskaracharya wrote commentaries on the work of Aryabhatta. He was the head of the astronomical observatory at ujjain. He had made fundamental contributions to the development of a number theory, algebra , theory of indeterminate infinite series expression for sine, cosine and computational mathematics.Throughout his life Bhaskarachaya produced few great works - Siddhant Shiromani, Karanakutuhal and Sarvatobhadrayantra. He has a daughter named Lilavati , to whom he dedicated a mathematical treatise written sometime in the middle of 12th century . Siddhanth Shiromani consists of four parts - Lilavati, deals mainly with arithmetic and geometry, Bijaganita is on Algebra, Grahganit and Goladhyaya are on astronomy.

Life and Works of Lilavati -

There are not much information about the early life of the Lilavati. She was a very beautiful child and very intelligent too. As a little girl she asked her father many questions and gained a lot of knowledge in mathematics. As she grew up, Bhaskara decided to get Lilavati married. Therefore he created a horoscope for his daughter Lilavati, which predicted that she would remain unmarried. Therefore to avoid this fate, he ascertained an auspicious moment for his daughter's wedding at the correct time so that it could be avoided. he placed a cup with a small hole at the bottom of a vessel filled with water, arranged so that the time at which the cup sank was the optimum time Lilavati was to get married (water-clock). He put the device in a room with a warning to Lilavati not go near it. In her curiosity though, she went to look at the device and a pearl from her bridal dress accidentally dropped into it, which blocked the hole and the lucky hour passed without the cup sinking. The auspicious moment for the wedding thus passed unnoticed leaving a devastated Bhaskaracharya. After the wedding her husband died soon after the ceremony. Bhaskara brought back his daughter to his residence. But She seemed disinterested in the normal day to day activities. She sat by the pond looking into nothingness and wept. She remained silent most of the time. Bhaskara found it very difficult to see these conditions of his beautiful daughter. He thought of a way to get her out of her depressed state. He posed 'Arithmetic Problems' at Lilavati about the things around her and asked her to find solutions to the problems. Lilavati, the brilliant girl that she was, solved all the problems posed to her. Lilavati's mind, which was busy in solving the mathematical problems posed by her father, never again got depressed. It is believed that the problems posed to 'Lilavati' form the major portion of 'Bhaskara's Treatise' which is named after her. Lilavati was given and could solve complex problems which are now resolved using the Pythogoras theorem. Thus Lilavati became one of the most eminent women Mathematicians of India. It should be remembered that Lilavati served as a textbook for nearly 800 years in different parts of India until the British system of

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education was introduced. This is something worth emulating in order to make mathematics education interesting, exciting and also fun.

Lilavati As a Text -

Lilavati was written in 1150 in Sanskrit Language and also composed in verse form so that pupils could memorize the rules without the need to refer to written texts. The book contains thirteen chapters and covers many branches of mathematics, arithmetic, algebra, geometry, and a little trigonometry and mensuration. The main content of Lilavati book deal with three main topics in mathematics, viz. (i) dealing with the rational numbers and their operational relation with one another; (ii) finding the areas and volumes of geometrical figures; and (iii) indeterminate equation of the first degree and combination. The whole text is prefixed with different tables of measurement of weights, volumes and length. Bhaskaracharya comments on the results of Brahmagupta and Sridhara about the quadrilaterals and improves the results of earlier authors in finding the volume of the sphere. Bhaskaracharya has not given proofs for his rules, but he has given a number of examples to verify the rules. The available editions of Lilavati have the total number of verses varying from 261 to 280.

Methods of Math Teaching -

During that time most books on mathematics prescribed for formal study are written in typical dull and dry style. Bhaskaracharya avoided this kind of writting style and make attempts to describe content in illustrative manners. He suggests multiple ways of dealing with a problem and allows the reader to choose the method of his or her choice.
In Lilavati, Bhaskaracharya correlate his mathematics with information on Vedas,
Puranas, Epics and Nature. In the problem on Arjuna's arrows he refers to the Mahabharata war. The graphic descriptions of the drove of swans, a flock of elephants, a colony of bees, the attack on a snake by a peacock, lotus touching the water surface being swayed by the wind and so on, inculcate appreciation of nature among the students to make mathematics more interesting. He tries to create interest among the readers through a variety of means. In some cases he presents the problem through a story. In other cases he creates interesting situations. Following is an example of how he created mathematical problems with great interest.

अस्त स्तंभतले बिलं तदुपरि क्रीडा शिखंडी स्थितः |
स्तम्भेहस्तनवोच्छिते तृगुणितस्तंभपमाणांतरे ||
दृष्टवाहिं बिलमा वृजंतमपतत तियर्क स तस्योपरि |
क्षिप्ं बूहितयोबि्लात्कतिमितैः साम्येन गत्योयृतिः|||

Example - A snake hole is at the foot of a pillar, nine cubits high, and a peacock is perched on its summit. Seeing the snake at a distance of thrice the pillar gliding towards the hole, he pounces obliquely upon him. Say quickly how many cubits from the snake's hole they meet, both proceedings an equal distance.

Commentaries on Lilavati -

Later on , Lilavati became the most popular mathematical text and many commentaries have been written on it. Even in the medieval period the great Mughal emperor ordered this work into Persian which was the official language of Mughal Emperors. On his order It was translated into Persian by Abul Fazal. There are two types of commentaries written on it first, deal with the meaning of the verses of the work and give its solution with examples while second attempt to provide *Upapattis* for the rules of the texts.

The most famous commentaries are -

Buddhivilasini of Ganesh Daivajna (15th CE) , *Kriyakramakari* of Sankara and Narayana (16th CE) and *Lilavati Vivarana* of Mahidhara (17th CE).

CONCLUSION

Lilavati's legacy endures as a reminder of the rich mathematical heritage of ancient India. In the tapestry of mathematical history, Lilavati emerges as a luminary figure, illuminating the path for generations of mathematicians to follow. The book's emphasis on practical applications, such as calculations involving interest, mixtures, and time, reflects its relevance to everyday life even centuries after its creation. Besides mathematical details the work Lilavati also provide us various contemporary historical records like types of weights and measurement as well as on types of coins.

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