Pedagogic Analysis of Bhaskaracharya's Lilavati

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Introduction

Lilavati, sometimes also called as patiganit, mainly discusses concepts in arithmetic. In addition, there are elementary concepts taken from Algebra and Geometry also. Here is short list of topics.

The entire book is written in poetic from. The capability of Bhaskaracharya as a litterateur is evident from the way he puts down the verses (shlokas) in the book. He has made profuse use of alankaras (figuresof speech) like pun, alliteration, metaphors and similes in his writing. There are about 270 verses in Lilavati. Only a few of them provide guidelines white a majority are used to raise questions. Although educational psychology was not a developed discipline in those days, Bhaskaracharya seems to be well aware of the pedagogical principles involved in the teaching of mathematics. The examples in Lilavati clearly bring out this fact. This paper attempts to present the analysis of Lilavati through the angle of pedagogue and highlight how relevant they are in the present situation.

Pedagogical Characteristics

Lilavati is a master piece as far as pedagogical guidelines are concerned. It advocated many useful pedagogical aspects that help the teaching of mathematics. Looking at Lilavati through this angle as a practising mathematics educator I see following pedagogic characteristics of Lilavati.

Gender equality

In the days of Bhaskaracharya the girls were discouraged from formal schooling. Even when the education was made available to girls many of them opted for softer subjects and avoided hard disciplines like mathematics (Ref GASAT). On this background it was revolutionary on the part of Bhaskaracharya to address mathematics problems to a female member through his writings. Bhaskaracharya certainly advocated gender equality through his writings as he refers to feminine words like bale, sakhe, charming girl, etc. in Lilavati. An example from the book along with its English translation is cited below. :

बाले बालकुरंगलोलनयने लीलावति प्रोच्यताम |

पंच्येकमिता दिवाकरगुणा अंकः कति स्युर्यदि||

रॉऑपस्थानविभागखंडगुणने कल्पासि कल्याणिनि||

छिन्नस्तेन गुणेन ते च गुणिता अंकाः कति स्युर्वद ||

A beautiful and dear Lilavati, whose eyes are like fawn's, tell me the numbers resulting from one hundred thirty five taken into twelve, if thou be skilled in multiplication by whole or parts whether by subdivision of form or separation of digits.

Building prerequisites
Mathematics is a hierarchical subject. It is well known that all that is learned earlier is essential to progress further in mathematics. If a student does not possess requisite knowledge or skills he/she would not be able to handle new situation. Bhaskaracharya attempts to explain the basic operations in mathematics like summing, squaring, etc. concepts. He goes to explain essential concepts like area, square root, trigonometric ratios, etc. Whenever required he has coined a new technical terms from Sanskrit root words. This aspect in my opinion is very important as many of the teachers complain for lack of technical terms to teach mathematics in regional languages in present situation.

Apart from explaining the requisite information the Bhaskaracharya also makes deliberate efforts to build requisites skills among the readers. For that he poses problems in a graded manner. This gradation not only helps them build necessary skills but also build a confidence to tackle problem in a new situation without any difficulty.

Motivation
Motivation is considered to be an essential component of learning. Unless the person is motivated the learning would not take place even if the teacher has completed teaching. Importance is, therefore, given in teaching to motivate the learner even before a task is given. Bhaskaracharya seems to be aware of this pedagogical fact. Hence, 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. A problem involving snake and peacock can be considered as an example in this category.

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अस्तिस्तंभतलेबिलंतदुपरिक्रीडाशिखंडीस्थितः|

स्तम्भेहस्तनवोच्छितेत्रिगुणितस्तंभप्रमाणांतरे||

दृष्टवाहिंबिलमाव्रजंतमपततितिर्यकसतस्योपरि|

क्षिप्रंब्रूहितयोर्बिलात्कतिमितैःसाम्येनगत्योर्युतिः||

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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.

Rapport building
Most of the times the book on mathematics prescribed for formal study is written in a dull and dry style. The entire book Lilavati is, however, written in first person active voice. The author addresses the reader with loving words like mitra and bale. At many places he addresses the readers as mathematician and instigates them to undertake problem solving.

Open endedness is the hallmark of Lilavati. Bhaskaracharya has not solved any problem in his book. He suggests multiple ways of dealing with a problem and allows the reader to choose the method of his or her choice. At some places he provides necessary hints but does not force the reader to follow a specific method. Here is an example from Lilavati as a part of kuttak method.

एकविंशतियुतं शतद्वम| यद्गुणं गणक पंचषष्टियुक||

पंच्वर्जितशतद्वयोध्दतम| शुद्धिदमेति गुणकं वदशु तत||

"Say quickly, mathematician, what is that multiplier, by which two hundred and twenty-one being multiplied, and sixty-five added to the product, the sum divided by a hundred and ninety-five becomes exhausted."

Content relevance

Studies show that students dislike mathematics as they find it irrelevant to their daily lives. Realising this fact Bhaskaracharya attempts to pose problems of daily relevance like income, area, stacking of bricks, etc. The problems are composed taking animate as well as inanimate objects found around. Thus snakes, bees, swans, elephants, etc. are referred to in the description. Apart from showing the relevance these problems create interest among the students for problem solving. Here is one such example from Lilavati.

यातंहंसकुलस्यमूलदशकंमेघागमेमानसं|

प्रोड्डीयस्थलपद्मिनीवनमगदष्टांशकोभस्तटात||

बालेबाल्मृणालशालिनिजलेकेलिक्रियालालसम|

दृष्टंहंसयुगत्रयंचसकलांयूथस्यसंख्यावद||

Out of the swans in a certain lake, ten times the square root of their number went away to Manasa Sarovarawhen rains started, and one eighth the number went away to the forest Sthala Padmini. Three pairs of swans remained in the tank, engaged in water sports. What is the total number of swans?

Field Experiences

In order to celebrate the 900th birth anniversary of Bhaskaracharya the Vidya Prasarak Mandal (VPM), Thane has decided to organise an international conference on the life and work of Bhaskaracharya. In addition, workshops were planned for students and teachers based on Lilavati. Starting from January about 50 workshops have so far been conducted in different schools and colleges in the states of Maharashtra, Madhya Pradesh and Andhra Pradesh. These workshops are conducted in two parts. The first part is devoted to familiarising the participants with the rich tradition of Mathematics in India. Bhaskaracharya is presented as a member of this tradition. Some information about his life and work is outlined. The second part of the workshop is used to deal with selected problems from Lilavati. These problems are chosen taking into account the educational background of the participants.

The experiences of conducting these workshops have been quite positive. Students,at different levels, find the task of solving problems from Lilavati very interesting. It is notable that the participants engage themselves in the task for almost three hours. On many occasions they come forward to solve problems on the blackboard. Due to educational practice that is followed in the school they do not appreciate the open ended approach advocated by Bhaskaracharya to begin with. Soon however, they start realising the importance of this method and come out with novel method of dealing with given problem. Let me share an experience that I had while solving the snake and peacock problem mentioned above. Standard method that is flowed in dealing with the problem is to apply Pythagoras theorem and find out the value of requisite distance. One boy however, came out 12 as the answer quickly. On enquiry he revealed that he tried to look for a triad having number 9 in it. Another boy went on adding square number to 81 (square of 9) and checked whether the answer is a square number. Through this method he also came out with an answer 12.

Conclusion and implications

It is clear that the pedagogical Characteristics of Lilavati are relevant even today. Efforts must be made to practice them in day to day teaching. I believe that the methods adopted by Bhaskaracharya would work both for first generation learners and traditional learners. It would, I am sure, enable us to make Indian citizens mathematically literate. We should be proud that we have an age old tradition of teaching mathematics effectively. It is high time that we make use of this traditional knowledge to improve teaching of mathematics in Indian schools and colleges. Constructivistic approach, Situational Learning and Experiential learning are the buzz words of present day pedagogy. Without saying it explicitly, Bhaskaracharya had adopted all of these pedagogic aspects in his writings. The very meaning of his name is Bhaskar the teacher (Acharya in Sanskrit means teacher). I once again salute this great teacher of India.