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School Mathematics in Colonial India: Analyzing an Arithmetic Textbook from the Late Nineteenth Century

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ABSTRACT This article analyzes a popular arithmetic textbook, *Arithmetic: For the Use of Schools and Colleges*, authored by Jadav Chandra Chakravarti, to examine the contents and pedagogies in the text for how mathematics was taught and learned from the end of the nineteenth century through the first half of the twentieth century in colonial India. The study findings provide us with a glimpse of the teaching and learning of mathematics in colonial India and help us to better understand current school mathematics and its curriculum evolution and development in the subcontinent. Even though Chakravarti's textbook is mainly based on rule-method pedagogy, it has simple descriptions of rules and procedures, and a gradual progression from simple to complex in exercises and topics, which was unique at the time. The textbook maintains coherence in its style and presentation of the contents, and engages students and teachers by reflecting social life and cultural traditions in colonial India, which perhaps contributes to a long period of popularity of this book in the Indian subcontinent. The textbook has its legacy in modern education in the Indian subcontinent. Still, in the subcontinent, textbooks are one of the main sources of mathematics teaching and learning, as well as test preparation for high-stakes exams.

KEYWORDS: *Colonial India, Indian subcontinent, Chakravarti, textbook anlaysis, school mathematics*

Introduction

Mathematics takes an important place in Indian civilization as well as in the current educational system in the Indian subcontinent. The current education system in the subcontinent, including mathematics education, mainly started in the time of Colonial India. The colonial roots of education and old textbooks made its impact and imprint on current curricular design and educational practices in India (Jain, 2015; Ghosh, 2015). In depicting the history of mathematics education in modern India, Raina (2014) refers to the popularity of using mathematics textbooks in colonial India. Aggarwal (2007) surveyed a list of colonial mathematics textbooks. Textbooks play central and authoritative roles in classrooms in India, which can be characterized as "syllabus society" or "textbook culture," for the contents and the pedagogical styles that textbooks use for the subject materials in classrooms (Jain, 2015; Pinar, 2015; Thapan, 2015). However, there exists a research gap about mathematics textbooks and their relation to mathematics teaching and learning in colonial India.

Analyzing historical mathematics textbooks would provide us with a glimpse of the teaching and learning of mathematics in colonial India and help us to better understand current school mathematics and its curriculum evolution and development in the subcontinent. The purpose of this article is to analyze a popular arithmetic textbook, *Arithmetic: For the Use of Schools and Colleges*, authored by Jadav Chandra Chakravarti, to examine the contents and pedagogies in the text for how mathematics was taught and learned from the end of the nineteenth century through the first half of the twentieth century in colonial India (Chakravarti, 1911).

Colonial India and its education system originated when the East India Company (EIC) came to India in 1600. In its earliest years, the company had no intention of being involved with the country's local administration and education system. Their focus consisted mainly of trading and business. However, as they extended their business and power, they became interested in the country's political affairs and policies, and later introduced colonial education in India. Macaulay's report in 1835 advanced the policy for English as a medium of instruction (Majumdar et al., 1946; Nurullah & Naik, 1943). Wood's dispatch in 1854 formalized the colonial education system (Majumdar et al., 1946; Nurullah & Naik, 1943). Then, a great number of mathematical textbooks were printed locally in India or imported from England (Raina, 2014). Chakravarti's arithmetic textbook was first published in English in 1890 in this formal colonial education system.

Research Methodology

On the methodology of analyzing historical mathematics textbooks, Schubring (1987) developed a conceptual framework, in which a popular textbook is selected, (which is Chakravarti's textbook, in this case), to examine for the representation of school mathematics during that period. Then the framework needs to consider the textbook author's biography and changes in books' multiple editions and relate those changes to the country's social contexts and educational policies. My research questions are: (1) What is the scope and sequence of the contents and the evidence of pedagogy embedded in the textbook? (2) How can the textbook contents and the evidence of pedagogy be related to school mathematics practice? (3) How can the textbook contents and the evidence of pedagogy be related to the mathematics curriculum in the sociocultural contexts in Colonial India?

Textbook Author's Biography

Almost nothing is known about Chakravarti's early life and biography. Ray (2023) recognizes him as one of the great mathematicians in India. Chakravarti was born in 1855 in Sirajganj district in present day Bangladesh. He completed his entrance examination in 1876. He then moved to Calcutta City to complete a Master of Arts degree in mathematics from the Presidency College, University of Calcutta in 1882. While he was in college, he taught physics and chemistry part-time at St. Paul Cathedral Mission College in Calcutta, in order to be able to pay his tuition. Later he took a job as a mathematics teacher in Calcutta City College. He joined as a mathematics professor at Muhammadan Anglo-Oriental (MAO) College at Aligarh (Aligarh Muslim University) in 1888. Before he joined MAO college, he also served as a colonial government officer in Cooch Behar (Ray, 2023; Pathan, 1984).

Chakravarti's biography provides us some colonial sociocultural contexts under which the textbook originated and developed, and his motivation for the choice of pedagogical styles observed in the textbook. When he was a mathematics teacher at City College, he wrote a mathematics textbook, as he did not find any mathematics textbook which could engage students and make mathematics interesting to them. During his professorship at MAO college, he finished and published the arithmetic textbook in 1890, which he began writing while at City College. He authored other textbooks on topics including geometry and algebra, but the arithmetic textbook brought him fame and popularity as a mathematics textbook author. Pathan (1984) praised the arithmetic textbook for its simplicity, easy accessibility, and engaging, yet difficult, mathematics for students and teachers. The textbook's effectiveness in making connections between mathematics and the world outside of the classroom is significant.

When Chakravarti joined MAO College, there was an anti-Bengali sentiment at Aligarh. However, with his social and academic reputation, he took the Registrar position of the college in 1899 in *addition* to the role of mathematics professor (Lelyveld, 1975; Pathan, 1984). Mahmood (1895) remarked about his friendly manner and mathematical reputation as follows:

> My worthy friend Babu Jadav Chandra Chakravarti, M. A., Professor of Mathematics in the Muhammadan Anglo-Oriental College at Aligarh, to whose mathematical talent and labour I am indebted for the elaborate calculations… and also for the ready assistance which he has kindly given me in connection with other statistics whenever I have had occasion to consult him. (p. vii)

MAO college also recognized his secular attitudes towards the Hindu and Muslim communities. During his professorship of mathematics, he contributed to the development of the mathematics department. Chakravarti, along with support from his former student Dr. Ziauddin Ahmed, organized a group of teachers and researchers, who were interested in astronomy, history of mathematics, and theory of functions, and helped to form the mathematics department. He retired from his job in 1916. Little information is known about how he spent the period after his retirement. He eventually

returned to his birthplace, Sirajganj, Bangladesh, and was elected chairman of the local town municipality. In Sirajganj, he also founded a school in 1901. He died in 1920 in his Calcutta residence (Ray, 2023; Pathan, 1984).

Textbook Contents

After the first publication of Chakravarti's textbook, *Arithmetic: For the Use of Schools and Colleges*, in 1890 (in English), it continued to be published for the next century, even after the independence of India (as my own father used this textbook after 1947). In the early part of the twentieth century, at the time of the nationalist movement in India, the textbook was translated from English to many major regional languages including Bengali, Hindi, Assamese, and Nepalese. The book's print was legible, and its language, including Bengali and English, is simple and standard. The local publishing company, Sanyal & Co. at Calcutta, first published the book and its multiple editions. The book does not include any pictures or illustrations, although the author uses diagrams of squares, rectangles, and parallelepipeds. The audience of this textbook is middle school and secondary school students, which the author explicitly mentions in the preface (Chakravarti, 1911).

The topics in the textbook include basic numeration of the decimal systems and operations of addition, subtraction, multiplication, and division; measurements of time, and angle; barter, gain, loss; factors, prime numbers, multiple factors; decimal numbers and fractions; square root and cubic root; proportion, rate, percent; profit, discount, interest, money exchange. The scope of the contents is generally the same in later editions. Other contemporary textbooks, including Smith's *Arithmetic for School* and Mukhopadhaya and Basu's *Patigonith*, have very similar contents (Smith, 1872; Mukhopadhaya & Basu, 1940). In addition, there exists consistency between the mathematics topics covered in the entrance exams of Calcutta University and other provinces (a reference to copies of old exams included in the back of Chakravarti's and Mukhopadhaya and Basu's textbooks) and the topics that the three textbooks covered (Chakravarti, 1911; Smith, 1872; Mukhopadhaya & Basu, 1940). Central and regional governments regulated the syllabus and curriculum for the high-stake entrance exams.

Textbooks prepared students to acquire mathematical knowledge and skills relevant to sociocultural life in colonial India. Chakravarti's textbook starts with tables of measures and units used in that period including the British money table (schillings, pence, pound, guinea), the Indian money table (pie, annas, rupee), English jeweller's weight (grain, pennyweights, ounces), English standard weight (drams, ounces, pounds, quarters), Indian bazar weight (sikis, tola, kancha, chataks, powas, seers, maund), other provincial local weights, English linear measurements (inch, feet, yard), and other Indian measuring systems. There are other topics related to Indian sociocultural life such as money exchange, the barter system, and the measurement of Indian land, among others. Here, there can be mentioned some examples about colonial life embedded in the text. Below are two word-problems, which do not provide any evidence of sociocultural life in colonial India:

> A merchant in New York wishes to remit to London 5110 dollars, a dollar being equal to 4*s*. 6*d*. English: for what sum in English money must he draw his bill when bills on London are at a premium of $9\frac{1}{2}$ per cent.? (Chakravarti, 1911, p. 343)
>
> There is also a physics problem here:
>
> "One pendulum oscillates 6 times in 3.2 seconds, and another pendulum 8 times in 3.6 seconds; if started simultaneously, how often will they tick together in an hour?" (Chakravarti, 1911, p. 297)

However, most of the word problems in the book represent the Indian traditional cultural elements, including the local currency (Rupees), transportation systems, and local measurement systems and units, which engage teachers and students in the teaching and learning of mathematics. For example, the following problem shows the local staple food (rice), and local measuring unit system (*maund*): "A man bought 35 *maunds* of rice on a certain day, and 9 *maunds* on the next day; how many *maunds* did he buy in all?" (Chakravarti,1911, p. 11). The word problems in the book maintain a balance of Indian colonial social life and Indian cultural traditions.

Here is another word problem that demonstrates an example of multi-ethnicities and races of a colonial town: "A certain town contains 87,903 Hindus, 48,093 Mahomedans, 723 Europeans, 1,309 Eurasians and 159 other races; What is the total population of the town?" (Chakravarti, 1911, p. 14). This example also demonstrates inclusivity in the context of race and ethnicity and the author's secular attitude towards different religions including Hindu, Muslim, and other religions, which perhaps increased the book's accessibility to different groups of people.

The following information demonstrates that the textbook had an authoritative role in school mathematics. The scope of the contents of Chakravarti's book and two other contemporary textbooks, including Smith's *Arithmetic for School* and Mukhopadhaya and Basu's

Patigonith, had been maintained almost without change in multiple editions, which indirectly shows the textbooks' central roles about what to teach in classrooms. One edition of Chakravarti's textbook mentions in the preface: "This edition has been specially adapted to meet the requirements of the new syllabus of study drawn up by the Education Department of Bengal. This has necessitated the fragmentary treatment of some of the subjects" (Chakravarti, 1930, p. ii). This provides further evidence of the textbook's authoritative role in mathematics curriculum because the textbook author prioritizes more to include exam topics than to fully develop the mathematics subject topics. The Education Department regulated the school mathematics curriculum, which was implemented through textbooks in classrooms and reflected in the topics of entrance exams. Textbooks play a significant role in preparing students for the entrance exams.

Pedagogy

The author's pedagogical vision is written in the preface section of the first edition of the textbook, where he emphasizes mathematical reasoning and understanding, starting from simple mathematical processes to complex processes:

> I have carefully avoided laying down arbitrary *rules* and have endeavoured to establish the leading propositions of the science of Arithmetic by a process of simple reasoning, being fully convinced that a mere mechanical facility in manipulating figures, sufficient though it may be for the calculations necessary in every-day life, is in no way conducive to a healthy development of the reasoning faculty. I have accordingly explained the processes of Arithmetic by means of specimen examples fully worked out, and in every division of the subject I have begun with simple principles and have tried to proceed by gradual and natural steps to those of a more complex nature. (Chakravarti, 1911, preface)

Here, I will mention some mathematics topics, considering their pedagogical perspectives. The author introduced the topic *addition* operation with definitions, symbols and notations, progressing to mental recitation of *addition* of small numbers and explanation of rules step by step. After the description of the procedures in the worked examples, the section provides exercises of many *addition* problems. For example, the book's *addition* section exercises start with a simple problem at the beginning: "I have purchased a table for 16 rupees and a chair for 7 rupees; how many rupees have I spent in all?" (Chakravarti, 1911, p. 10). Then, a somewhat more complex problem can be mentioned located at the end of the same *addition* exercises: "From a rope are cut off first 27 yards, then 8 yards, and there are 7 yards left; what was the length of the rope?" (Chakravarti, 1911, p. 11).

In the next section, the author also explicitly describes the *addition* rule step by step in simple ways for bigger numbers of 378, 409 and 56:

> We write down the numbers, one under another, thus
>
> ```
>  378
>  409
> +  56
> ----
>  843
> ```
>
> placing units under units, tens under tens, hundred under hundreds, and so on; then draw a line under the lowest line of figures. Under this line we place sum which is found in the following way:
>
> We first add the units, thus (8+9+6) units = 23 units = 2 tens + 3 units; we place 3 under the column of units and *carry on* the 2 tens for adding to the column of tens. Next we add the tens, thus (2+7+0+5) tens = 14 tens. … and we place the 8 under the column of hundreds. (Chakravarti, 1911, pp. 11-12)

It is noticeable that the sequence of exercises progresses from simpler to more complex. The example also shows that the author explains the procedures in simple language and in an easy-to-follow fashion. This pedagogy follows throughout the textbook in various mathematical topics.

However, in the above *addition* example, there can be examined another dimension of pedagogy that the textbook reflects throughout the book, which emphasizes rules and procedures to follow rather than inquiry and a constructivist approach. A procedure-based method can be conceptualized as memorizing the rules and procedures and practicing them in the mathematics tasks. On the contrary, in an inquiry-based and constructivist approach, students would be involved in discovering the mathematical formulas and algorithms (rules) as they explore the inquiry-based mathematical activities and problems (Michalowicz & Howard, 2003). In introducing the *addition* topic, the author approaches the conception of *addition* by demonstrating only rules to follow, rather than employing any mathematical tasks for exploring the conception of *addition* and constructing knowledge of mathematics. This procedures- and

rules-based method, in general, is applied to other topics too. The book also suggests that sometimes rote memorization learning practice, such as using an algorithm to find the Lowest Common Multiple (LCM), can be beneficial. Chakravarti introduces the LCM algorithm in the Lowest Common Multiple topic without mentioning the reasoning and explanation of how the algorithm functions:

> The following rule gives the most convenient method of finding the L.C.M. of several small numbers:
>
> Places the numbers side by side in a line; divide by any one of the prime numbers 2, 3, 5, 7, 11, ……. which will divide any two at least of the given numbers exactly; set down the quotients thus obtained and the undivided numbers side by side; and proceed in this way until you get a line of numbers which are prime to one another. The continued product of all the divisors and the numbers in the last line will be the L.C.M. required. (Chakravarti, 1911, p. 84)

He then gives an example on how to use this algorithm to find the LCM of some numbers.

The book's different topics also maintain coherence and consistency in which earlier knowledge and skills are applied to current topics. Each topic starts with simple definitions and notations, several worked examples, and many exercises. This style of presentation is consistent throughout the book. In *addition*, Chakravarti's textbook occasionally includes exercises on miscellaneous topics in different locations of the book (review problems) to connect previous topics and concepts with new ones, which makes the textbook more coherent and connected. The book's ample number of exercises, including two *addition*al exercises on miscellaneous topics at the end of the book, give students and teachers wide and flexible opportunities to learn and teach mathematics, both in class and at home. These exercises also reflect students' better preparation for entrance exams, as many of the problems are collected from different sets of the entrance exams.

Chakravarti notes, "And I may add that although the book contains nothing that might strictly be called original, yet it will be found to differ in many ways from any existing text-book on the subject" (Chakravarti 1911, preface). The book's unique styles and pedagogical techniques support this claim. Chakravarti's textbook demonstrates a unique feature in connecting mathematics outside of the classroom to colonial life and Indian traditional culture, and its use of simple and easy-to-follow language in describing the rules and explanations in comparison to two other contemporary textbooks. For example, most of the mathematical problems in Smith's book do not connect to colonial life and Indian traditions, although the book occasionally includes reasoning in describing rules and procedures, and the language of the text is simple and coherent. In contrast, many mathematical problems in Mukhopadhaya and Basu's textbook demonstrate connections to colonial society and Indian culture, although the consistency and coherence of the text in describing the rules and procedures of mathematical conceptions are not consistently maintained. For example, in introducing and describing the rules of *addition*, the authors, to some extent, do not coherently develop the rules of *addition* to follow. Moreover, Chakravarti's book provides many more problems for practice in class and at home in comparison to those of the other two textbooks.

Discussion and Conclusion

The limitation of this study is that there are few surviving documents about the biography of the author, and almost no research or review articles regarding the textbook. From the analysis of the contents and the pedagogical strategies in the text, considering its different editions until 1947, the year of independence of India, and comparing other related mathematics textbooks, this textbook provides a window to how mathematics contents were learned and taught in the contexts and social needs of colonial India in that period. Colonial government regulated school mathematics syllabi, curricula, and entrance exams. In this regard, the textbook plays a dominant role in high-stakes entrance exams preparation, both in terms of contents and rule-based pedagogies in mathematics practice. Even though Chakravarti's textbook is mainly based on rule-method pedagogy, it has simple descriptions of rules and procedures, and a gradual progression from simple to complex in exercises and topics, which was unique at the time. The textbook maintains coherence in its style and presentation of the contents, and engages students and teachers by reflecting social life and cultural traditions in colonial India, which perhaps contributes to a long period of popularity of this book in the Indian subcontinent.

The textbook has its legacy in modern education in the Indian subcontinent. In the subcontinent, textbooks are one of the main sources of mathematics teaching and learning, as well as test preparation for high-stakes exams.

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