

Gopal Pandey's Contributions to Nepali Mathematics through "Wyakta Chandrika"

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<p>Article info: Received: February 9, 2024 Revised: March 11, 2024 Accepted: March 27, 2024</p> <p>Keywords: <i>Gopal Pandey, Wyakta Chandrika, Nepali mathematics, mathematical education, historical context</i></p>	<p>Abstract: This study reviews the pioneering work of Gopal Pandey and his influential textbook "Wyakta Chandrika" in shaping Mathematical education in Nepal. Beginning with an overview of the historical context of education in Nepal, including the establishment of formal schooling and the contributions of early scholars, the research focuses on Pandey's life and his journey as a Mathematician. It examines the content and significance of "Wyakta Chandrika," highlighting its role in imparting Mathematical knowledge and fostering cultural awareness among students. Additionally, the study analyzes the impact of Pandey's innovative methods, such as the trinomial method for finding cube roots, and explores the evolution of Mathematical literature in Nepal following the publication of "Wyakta Chandrika." Through an analysis of the book's contents and its implications for Mathematical education, this research provides insights into the enduring legacy of Pandey's work and its continued relevance in contemporary Nepali Mathematics.</p>
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Introduction

The introduction of formal schooling in Nepal marked a significant shift from the traditional Gurukul system, with the establishment of the Nepal State Sanskrit School in 1877 A.D., Prior to this, efforts towards education were evident in the early 1853 A.D. Despite the modernization of education, accessibility remained limited, leaving many without formal schooling. However, Nepali scholars continued to contribute to literature, with works like Acharya Sumati's and Ratna Deep's focusing on various subjects including astrology and Mathematics (Acharya, 2010 and Pandit, 2011).

Gopal Pandey, born in the Gorkha district of Nepal in 1847 A.D., emerged as a prominent figure in Nepali Mathematics. His journey from home education to studying under distinguished Mathematicians in Kathmandu and Varanasi, and later becoming a Mathematics teacher at Ranipokhari Sanskrit School, reflects dedication to the field. Throughout his tenure, Pandey authored instructional texts like "Wyakta Chandrika," aimed at simplifying arithmetic concepts and fostering Mathematical proficiency among students. He authored the groundbreaking Nepali math book, "Wyakta Chandrika", which introduced the cube root calculation method using the Rule of Three or *Trizoidiaacle* method (Upadhyay, 2002).

Pandey also penned *Lokanu Smiriti*, discussing democracy, and significantly contributed to the development of *Tundikhel* for the Nepalese Government. Additionally, his calendar revisions were recognized and honored by the government. Hailing from a lineage deeply rooted in the region, Gopal Pandey's contribution to Nepali Mathematics is significant, as he is the first Mathematician and writer of Mathematics books in the Nepali language among the known Mathematicians in Nepal (Acharya, 2015).

"Wyakta Chandrika" by Pandey (1883) is a cornerstone of Nepali Mathematics education, delving into arithmetic and geometry. It is divided into sections on numerical proficiency, measurement systems, geometry, and practice problems, providing students with essential Mathematical skills while

promoting cultural awareness. Pandey's innovative methods, like the trinomial method for cube roots, challenged conventional wisdom and advanced Mathematical literature in Nepal (Acharya, 2012).

This textbook was printed on locally crafted Nepali paper, marking a pivotal moment in Nepal's math education. This publication not only showcased the use of printing technology but also presented an updated version of the renowned *Lilavati*, extending its influence beyond the Himalayan region. Due to its popularity, subsequent editions followed: a second edition in 1895 A.D., a third edition in Hindi in 1907 A.D., and a fourth edition in Nepali in 1914 A.D., this enduring textbook remains an integral part of the Nepali curriculum, providing a comprehensive exploration of arithmetic and geometry (Upadhyay, 2009 and Maskey, 2013).

In 1884, a Pachanga was first published in Nepal. Pandit Pandey discovered errors in the lunar eclipse forecast and swiftly released a corrected version during the event, proving accurate over time. Recognizing his expertise, the Rana Ruler awarded him *Dosalla* and a salary increase of Rs. 500. This showcased Pandit Pandey's astronomy skills. Tragically, he passed away in Kashi, India, in 1920 A.D., a year after retiring (Upadhyay, 2009).

Even with advancements in education, many lacked access to formal schooling. Nevertheless, Pandey's dedication to simplifying arithmetic and nurturing Mathematical skills through "*Wyakta Chandrika*" has significantly influenced the educational landscape, leaving a lasting impact (Pandey, 1883).

Research Problem

Despite its historical significance, there remains a gap in understanding the full extent of "*Wyakta Chandrika's*" impact on Nepali Mathematics education. This research seeks to address this gap by conducting a comprehensive analysis of the content, pedagogical approaches, and perceived relevance of "*Wyakta Chandrika*" among stakeholders in Nepali Mathematics education.

Objectives

To explore the contributions of Gopal Pandey to Nepali Mathematics education through an analysis of his book "*Wyakta Chandrika*".

Research Methodology

This research employs a qualitative research approach to investigate the significance of "*Wyakta Chandrika*" in Nepali Mathematics education. The methodology involves:

Literature Review: Conducting a comprehensive review of existing literature on Nepali Mathematics education, Gopal Pandey's contributions, and the significance of "*Wyakta Chandrika*".

Content Analysis: Analyzing the structure, topics covered, and instructional methods of "*Wyakta Chandrika*" to understand its content and significance.

Overall, the research highlighted "*Wyakta Chandrika's*" importance as a foundational text in Nepali Mathematics education, its influence on pedagogical practices, and its enduring legacy in shaping Mathematical learning in Nepal.

Literature Review

Gopal Pandey, born in Nepal's Gorkha district in 1847 A.D., came from a family with deep roots in the region. His father, Bali Ram Pandey, and grandfather, Mani Ram Pandey, hailed from the same district, belonging to the "*Batsa Bhargava Gotra*." Gopal Pandey was the descendant of Laxmi Pati Pandey. He holds the distinction of being the first Mathematician and author of Mathematics books in the Nepali language among the known Mathematicians in Nepal (Acharya, 2010).

He holds the distinction of being the first individual to pen Mathematical texts in the Nepali language, as highlighted by Jha, Adhikari, and Pant (2006). The pioneering work attributed to him is the book titled "*Wyakta Chandrika*," published in 1883 A.D. This book, based on the *Lilabati* of Bhaskaracharya's (2006), marked a significant milestone in Nepali Mathematical literature. Gopal Pandey, renowned as a Mathematician and educator of his time, demonstrated his ingenuity by devising methods for finding square roots and cube roots, showcasing his individuality and originality in mathematical exploration.

Recognized for his scholarly contributions, Gopal Pandey's "*Wyakta Chandrika*" became a widely acclaimed textbook for Mathematics instruction during that Rana Era (Raikhola, 2020). Notably, Pandey introduced the *Trizoidiacle Rule*, a novel approach facilitating the calculation of square and cube roots, as documented by Pant (1980). This innovative method stands as a testament to Pandey's remarkable contribution to the field of Nepalese Mathematics, leaving an indelible mark on the discipline's evolution (Jha, Adhikari, and Pant, 2006).

Gopal Pandey made significant contributions to the field of Mathematics through his acclaimed writings, which gained popularity not only in Nepal but also in India. One of his notable concepts pertained to the Rule of Three in square root and cube root calculations, which differed from Bhaskaracharya's traditional view. While Bhaskaracharya asserted that the *Rule of Three* was not applicable to square roots and cube roots, Pandey contested this notion in his book "*Wyakta Chandrika*" (Pandey, 1883]. Unfortunately, this book is now rare and found only in a few libraries in Nepal. However, the technique for determining cube roots, as elucidated by Pandey, was elaborated upon by Prof. Naya Raj Pant in his 1980 publication "*Pandit Gopal Pandey Ra Unko Ghanmul Lyaune Reeti*." (Pant, 1980).

In addition to his Mathematical prowess, Pandey also exhibited expertise in other domains. He authored a book in Hindi, and his work "*Lokano Smriti*" delved into topics related to *Loktantra* (Acharya, 2010). Furthermore, Pandey demonstrated proficiency in architecture and engineering, notably contributing to the development of *Tundikhel*, a significant area in Nepal overseen by the government (Acharya, 2011).

Formal schooling in Nepal commenced in 1877 A.D. with the establishment of the Nepal State Sanskrit School, marking a departure from the traditional Gurukul system (Upadhyay, 2009). Prior to this development, in the early 1853 A.D., individuals brought in foreign teachers to Mathapathali Darbar, indicating initial endeavors towards educational advancement. Nevertheless, during the process of modernization, Darbari schools remained elitist, resulting in a significant portion of the populace being deprived of educational opportunities.

Despite obstacles, Nepali scholars persisted in their literary endeavors, producing notable works such as Acharya Sumati's "*Sumatitantra*" and "*Sumati Karana*" from antiquity, alongside "*Ratnadeep*" in the 18th century, which predominantly focused on astrology. The late 1743 A.D. marked the inception of Mathematical literature in Nepal, exemplified by publications like that of Gopal Pandey, the nation's first Mathematics educator. However, Pandey's contributions remain relatively obscure among contemporary Mathematicians, underscoring the significance of exploring his writings to fully appreciate his impact (Pant, 2004 and Upadhyay, 2009).

The earliest Mathematical concepts in India, rooted in the Vedic period, are evidenced in ancient sacred texts like the Vedas. These texts contain basic arithmetic operations like addition, subtraction, multiplication, and division. Additionally, the *Sulba Sutras*, associated with the Vedas, offer methods for constructing precise geometric shapes for altars and fire pits, showcasing early Indian proficiency in geometry and arithmetic (O'Connor & Robertson, 2000).

During the classical era, Indian mathematicians, particularly associated with the "*Shulba Sutras*," made significant strides in arithmetic. Noteworthy figures like *Baudhayana*, *Apastamba*, and *Katyayana* contributed significantly to arithmetic's development. Aryabhata, a renowned mathematician from the

5th century CE, introduced groundbreaking concepts such as zero and the decimal place value system, alongside methods for handling large numbers. Brahmagupta, who lived in the 7th century CE, further refined the Indian numeral system and established rules for arithmetic operations involving negative numbers and zero (O'Connor & Robertson, 2000).

Indian mathematics continued to flourish during the medieval period, particularly under the patronage of various Indian kingdoms. Bhaskara II, a mathematician from the 12th century CE, made significant contributions to arithmetic and algebra. His work "*Lilavati*" covers various arithmetic topics, including operations, fractions, and solutions to indeterminate equations (Bhaskaracharya, 2006).

Throughout his tenure, he authored instructional texts like "*Wyakta Chandrikana*," aimed at simplifying arithmetic concepts. His literary contributions extended to works like "*Bhubhramana Vikhaar*" and "*Lokanu Smritinam*." Notably, Pandey's Mathematical prowess garnered recognition when he rectified eclipse predictions in 1884 A.D. and 1901 A.D., earning accolades for his accuracy. His groundbreaking work included devising a method to calculate cube roots from trinomials, challenging prevailing beliefs among senior Mathematicians (Shrestha, 2017 and Pant, 2004).

Content Analysis of "Wyakta Chandrika" (Pandey, 1883)

The first section of "*Wyakta Chandrika*" serves as a foundational platform for numerical proficiency. It doesn't just teach students how to perform basic arithmetic operations like addition, subtraction, multiplication, and division; it also delves into the underlying principles behind these operations. This section also includes like Infinity, Direct Variation, Inverse Variation, Join or Compound Variation, Exchange of goods and Mishra Ganita, Bilom Bidhi, Dristi karma and Barga Karma. By providing practical examples and real-life applications, Pandey ensures that students not only learn how to crunch numbers but also understand why these Mathematical concepts matter in everyday life.

Moving on to the second section, "*Wyakta Chandrika*" tackles the intricacies of measurement systems prevalent in Nepal. From traditional currency units to regional customs governing land measurements, Pandey meticulously explains each aspect, contextualizing Mathematical principles within the socio-cultural fabric of Nepal. By doing so, the book not only equips students with Mathematical skills but also fosters cultural awareness and appreciation (Upadhyay, 2002).

The third section of "*Wyakta Chandrika*" dives into the realm of geometry, covering topics such as angles, triangles, parallel lines, and the calculation of areas and volumes for various geometric shapes. Through clear explanations and illustrative diagrams, Pandey demystifies geometric concepts, making abstract notions tangible and accessible to students. Moreover, by exploring practical applications of geometry in fields like land surveying and architectural design, "*Wyakta Chandrika*" underscores the relevance of Mathematical principles in real-world scenarios.

Finally, the fourth section of "*Wyakta Chandrika*" offers a wealth of practice problems accompanied by solutions. By engaging with diverse problem sets spanning arithmetic, geometry, and practical scenarios, students not only reinforce their understanding of Mathematical concepts but also sharpen their analytical and problem-solving skills (Upadhyay, 2009).

Analysis, Discussion, and Evaluation of "Wyakta Chandrika"

"*Wyakta Chandrika*" emerges as a seminal contribution to Nepali Mathematical education, embodying a holistic approach that integrates Mathematical principles with cultural relevance and practical application. The linguistic fusion of Nepali and Sanskrit within the text enhances its accessibility and instructional efficacy, catering to a diverse spectrum of learners.

Moreover, "*Wyakta Chandrika's*" alignment with the Nepali Math curriculum and its integration of practical examples testify to its utility as a pedagogical tool. By fostering critical thinking, problem-

Figure 1: “*Wyakta Chandrika*” book of Gopal Pandey (Maskey, 2013, Acharya, 2017 & Shrestha, 2017).

Some Examples From “*Wyakta Chandrika*”.

Calculation of Cube root

In 1980, Naya Raj Pant simplified and evaluated Gopal Pandey's method for computing cube roots. Subsequently, Eka Ratna Acharya conducted a further analysis and suggested alternative procedural steps (Acharya, 2010 and Acharya, 2015).

The steps to be followed for the calculation of cube root of 123456789 are as follows:

1. Mark the points above the digits at last on right then leave two digits toward left and put points each time. Such as the first point is marked above 9, second above 6 and third above 3 like, 123456789.
2. Count the number of points marked above the digits which give the number of digits of the cube roots with leaving the digits for decimal place of the cube roots. Here the number of digits in the cube root is 3, since there are 3 points.
3. Assume that the number holds the first point from left (or last point from the right) as a single number and subtract the possible cube of a number from it. Here the first point from left holds up to 123, so we should subtract the cube of 4 that is 64 and take down the digits up to 2nd point and note that 4 is the first digit from the left of the cube root.

$$\begin{array}{r} 123456789(4 \\ \underline{-64} \\ 59456 \end{array}$$

4. From (3) we get 59456 then we should multiply 59456 by ten and divide it by the number as the multiple of 1000 in the relation of the difference of cube of (first digit of cube root +1) and the cube of the first digit of the cube root. Here this two numbers are 5^3 and 4^3 and their difference as explained above is $125 - 64 = 61$.
5. Then from (4) we have,

$$61000)594560(9$$

Then we get 2nd digit of the cube root i.e. 9. Thus, the number is 49. Again, processed as (4) we get, $50^3 - 49^3 = 7351$ and $49^3 = 117649$

6. Again, subtract cube of 49 from 123456789 and take down the digit up to 3rd point as follow:

$$\begin{array}{r} 123456789 \\ \underline{-117649} \\ 5807789 \end{array}$$

7. Divided as in (5) we get,

$$\begin{array}{r} 7351000)5807890(7 \\ \underline{-51457000} \\ 6620890 \end{array}$$

8. $(497)^3 = 122763473$ then

$$\begin{array}{r} 123456789 \\ \underline{-122763473} \\ 693316 \end{array}$$

Therefore, the digits of the cube root before the decimal place are 497.

This concludes the digits of the cube root before the decimal point.

Next, for the digits after the decimal point, we introduce three zeros to the remainder obtained previously and continue following steps (4) and (5). It's worth noting that the difference of the cube, as mentioned in step 4, can be obtained as follows.

$$(498)^3 - (497)^3 = 3\{(497)^2 + 497\} + 1 = 742519$$

9. 742519000)6933160000(9

Thus, the cube root of 123456789 = 497.9 (Acharya, 2010).

"It is quite easy to calculate the cube root of a perfect cube. For determining the cube roots of numbers such as 2, 8, 24, and $2/3$, Pandey proposed a method: 'If there remains a remainder, introduce three zeros at each step and calculate the roots.'

"If the number is a fraction, multiply both the numerator and denominator by a number such that the denominator becomes a perfect cube. Then, divide the cube root of the numerator by the cube root of the denominator." This method, described by Acharya (Acharya, 2015), is quoted by Naya Raj Pant in his aforementioned book. Similarly Pant and Acharya simplified the study for the calculation of cube root of 2 as in the example.

The steps are as follows:

Calculation of Cube Root of 2

- i. $\frac{-1}{1000}$ (by introducing three zeros)
- ii. $2^3 - 1^3 = 8 - 1 = 7$ as previous example

In other words,

$$2^3 - 1^3 = 3(1^2 + 1) + 1 \\ = 3 \times 2 + 1 = 7$$

- iii. $7 \times 100 = 700$, here we should multiply the difference by 100 then

$$\begin{array}{r} 700 \ 1000 \ (1 \\ -700 \\ \hline 300 \end{array}$$

Using approximation, 2 is determined to be the second digit of the cube root.

- iv. $(12)^2 = 144$, $(12)^3 = 1728$. and $(13)^2$

$$\begin{aligned} (12)^2 &= 3(12^2 + 12) + 1 \\ &= 3(144 + 12) + 1 \\ &= 3 \times 156 + 1 = 46900 \text{ (by the multiplication of 100)} \end{aligned}$$

Then $\frac{2000}{-1728}$
 272000

By approximation the 3rd digit of cube root is 6. v. But $(126)^2 = 15876$ and $(126)^3 = 2000376$,

- v. But $(126)^2 = 15876$ and $(126)^3 = 2000376$, $(125)^2 = 15625$ and $(125)^3 = 1953125$

Since 2000376 cannot be subtracted from 2000000 so the 3rd digit is 5. Since 2000000 - 1953125 = 46875

- vi. $(126)^3 - (125)^3 = 3\{(125)^2 + 125\} + 1$
 $= 3 \times 125(125 + 1) + 1$
 $= 375 \times 126 + 1$
 $= 47251$

Additionally, we possess:

4725100)46875000(9

Therefore, the approximate cube root of 2 is 1.259 (Acharya, 2010 and Acharya, 2015).

Pandey's method garnered widespread acceptance among Mathematicians in Nepal and neighboring countries. The rule of three for determining cube roots was considered a significant achievement at the time. Naya Raj Pant endorsed this technique and extensively discussed it in various journals such as "Purnima" and in publications like "Pandit: Gopal Pandey and his Method of Getting Cube Root," released by the Royal Nepal Academy in Kathmandu in 1980. Pant's credibility was further solidified when he accurately predicted the annular eclipse on November 23, 1965, in Nepal. His acknowledgment of Pandey's accurate calculation earned him recognition from the Government of Nepal. Pandey's development of a distinctive method for finding the cube root of a positive integer showcased his keen interest in exploring novel mathematical derivations (Acharya, 2010 and Shrestha, 2013).

Conclusion

Gopal Pandey's book "*Wyakta Chandrika*" left a significant mark on Mathematics education in Nepal. It introduced innovative methods, like the trinomial method for finding cube roots, showcasing Pandey's ingenuity and expertise in Math. While these methods didn't become widespread, they demonstrated Pandey's unique approach to problem-solving.

Following "*Wyakta Chandrika*", a wave of Mathematical literature emerged in Nepal. Authors like Prakash Chandrika, Pahal Man Singh Swar, and Jai Prithvi Bahadur Singh continued to build on Pandey's work, contributing to the growth of Mathematical knowledge in the country. This lineage of authors continued with successors like Nurudatta Pandey, Viraj Pandey, and Merunath Pandey, each adding their own insights and techniques to the field.

"*Wyakta Chandrika's*" influence transcends its time. It has inspired generations of Mathematicians and shaped the way Mathematics is taught in Nepal. Its methods and ideas continue to be relevant, guiding the development of Mathematical education in the country.

As Nepal's Mathematical journey progresses, "*Wyakta Chandrika*" remains a symbol of innovation and excellence. Its legacy persists, reminding us of the importance of creative thinking and dedication to advancing Mathematical knowledge.

Acknowledgements

I'm deeply grateful to Gopal Pandey for his groundbreaking work, "*Wyakta Chandrika*," which transformed Mathematics education in Nepal. His innovative methods, like the trinomial method for cube roots, still inspire Mathematicians today. Pandey's legacy endures, shaping education and fostering excellence in Mathematics.

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