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Integrating Aryabhata's Kuttaka Method into Contemporary Mathematics Education: A Narrative Review of Pedagogical Potential

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ABSTRACT

The Kuttaka method, an ancient Indian algorithm provided by Aryabhata, is an important landmark in the solutions of Linear Diophantine equations. The study deals with the mathematics involved in the Kuttaka method, its historical evolution and its implications in modern mathematics teaching and learning. Its systematic approach and iterations represent the beginning of algorithmic thinking and it looks strikingly similar to the Euclidean algorithm. The paper provides a qualitative review of relevant literature on the use of Kuttaka method to enhance students' understanding of number theory and computational thinking skills. It identifies the significance of the method holding a comparison with other proven ethnomathematical traditions. The review also analyses the relevance of the method in the mathematics education and identifies the limited representation of Indian indigenous techniques in the present curricula. It argues and provides evidences for incorporating Kuttaka method in the secondary school curricula to promote and embrace culturally relevant pedagogy and Indian knowledge system (IKS). Moreover, the relevance of the method in the fields of cryptography and astronomy proves its importance and its inclusion in the modern curricula is in tune with the present-day educational objectives including NEP-2020. The study concludes with suggesting ways of curricula inclusion and preparedness of teacher for fruitful transaction of the method, discusses its challenges for classroom integration and also opens avenues for exploring the indigenous mathematical approaches in contemporary education.

Keywords: Kuttaka method, Diophantine equations, algorithmic thinking, computational thinking, Indian Knowledge Systems (IKS).

INTRODUCTION

Numerous treasures in the area of Algebra and number theory have sprouted from the Indian Knowledge System (IKS). One of the foundations or legacies of mathematics is the Kuttaka method, which literally means "Pulverizer", in other words breaking down a complex structure into simpler parts. This approach is an orderly method for solving the linear Diophantine equations of the standard form ay-bx=c (Saini, 2024; Sinha, 2025).

The linear equations in two variables, usually written as ax+by=c are an essential element of algebra. If our solutions are constrained to integers, such equations can be considered as linear Diophantine equations requiring special solution methods (Opeyemi et al., 2025). One of these methods is the Kuttaka, first mentioned by Aryabhata I in 499 CE, and later improved upon by Bhaskara I and Bhaskara II. Kuttaka is the one of the earliest known formal methods for finding integer solutions of indeterminate equations involving two variables (Saini, 2024). It was primarily utilized to solve astronomical challenges associated with planetary cycles, demonstrating an early grasp of modular arithmetic (Jain, 2017).

Current secondary level curricula introduce linear equations via graphical or algebraic substitution. Such techniques often do not emphasise the requirement for integer solutions. These precisions are essential for cryptography, computer science and astronomical calculation. In fact, studies says that Kuttaka allows mathematicians to perform problem solving attributes by repeatedly converting large coefficients into manageable remainders, until they have a distinct and exact solution (Dumka et al., 2025). This algorithmic flow mimics the Extended Euclidean Algorithm, yet it provides a much more intuitive tabular framework for learners to internalize the shifting relationships between quotients and remainders (Dutta, 2007). Therefore, there is a strong need to revisit the pedagogical value of the Kuttaka method and advocate for its inclusion in secondary education.

REVIEW OF RELATED LITERATURE

The Kuttaka method in Aryabhata's Aryabhatiya (499 CE) provides a systematic method for solving linear indeterminate equations. This method is one of the earliest algorithmic approaches for solving the equations of the type ay-bx=c and scholars have noted that it reflects sophisticated algebraic thinking in ancient India (Jain, 2017; Dutta, 2004). Modern reconstructions have portrayed this as a systematic, stepwise procedure that iteratively “pulverizes” coefficients into simpler equivalent equations, reflecting a concern with standard algorithms that characterized Hindu mathematics (Shang, 2009; Jain, 2017).

Historical investigations reveal that the Kuttaka method was developed several centuries before a similar development in European mathematics. Linear indeterminate equations were also worked on by later European mathematicians, such as Bachet and Euler, but the method for general solution was already developed by Aryabhata in the 5th century (Basar et al., 2022). This makes the Kuttaka method a wonderful contribution to the world’s heritage of mathematics. Again, historical studies emphasize that the emergence of this method was closely associated with astronomical computations that required accurate integer solutions for the calculations of planetary positions and calendar systems (Shukla, 2015).

The ideas underlying the Kuttaka method are relevant in mathematics of today. Linear Diophantine equations are very important in number theory, cryptography and in the design of algorithms. Recent studies have demonstrated that Aryabhata’s algorithm can be understood in terms of modern mathematical frameworks and can be applied to computational problems such as modular arithmetic and cryptographic systems (Kak, 2010). This link demonstrates the significance of ancient mathematical knowledge for modern scientific fields.

Recently, there has been an increasing interest in comparing more classic Indian approaches with modern approaches for teaching mathematics. Results of empirical research suggest that employing indigenous methods such as those using Aryabhata work can improve student interaction, conceptual understanding and problem-solving speed (Thakkar et al., 2025). In addition, experimental work on adding ancient Indian methods into middle-school instruction has demonstrated gains in speed, accuracy, engagement, and decreased mathematics anxiety along with serious worry over historical authenticity and conceptual depth (Ibrahim et al., 2025). Consequently, this literature advocates recognizing Kuttaka not just as an important historical algorithm in number theory but also a vehicle to combine IKS, algorithmic thinking, and Diophantine reasoning into upper secondary mathematics.

OBJECTIVES AND METHODOLOGY

The present study aims to explore the importance of Kuttaka method in the modern educational scenario for solving linear Diophantine equations. It aims to investigate its algorithmic structure, compare it with existing algorithms such as the Euclidean algorithm, and evaluate its contribution to the advancement of algorithmic and computational thinking in contemporary mathematics education. The study also explores the need for integrating the method in the present education system and embrace our knowledge system.

The current study is qualitative, descriptive, and exploratory. It relies entirely on secondary sources of data. The study uses a review-based research method to look into the historical importance, teaching relevance, and curriculum opportunities of integrating the Kuttaka method in secondary maths education. The research mainly focuses on themes like ethnomathematics, Indian Knowledge Systems (IKS), computational thinking, and culturally responsive math education. Data for the study were gathered from various secondary sources, including research articles, books, journal papers, conference proceedings, curriculum documents, policy reports, dissertations, and online academic databases. The mathematical efficiency and educational value of this method are analyzed from the perspective of comparative and thematic analysis.

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Steps of Solving a Diophantine Equation Using Kuttaka and Euclidean Method

Let us consider a linear Diophantine equation 60y-13x=1.

Steps of Kuttaka Method

1. A matrix grid is prepared using the successive division.

1 (Q2)	13 (coefficient of x)	60 (coefficient of y)	4 (Q1)
1 (Q4)	5(R2)	8 (R1)	1 (Q3)
	2 (R4)	3 (R3)	1 (Q5)
		1 (R5)	

Here Q1, Q2, Q3, Q4 and Q5 are the quotients obtained on successive division and R1, R2, R3, R4 and R5 are the remainders obtained on successive division.

2. Arrange the quotients and consider G1=0 and G2=1in a matrix grid in the way as shown below:

4 (Q1)	G7
1 (Q2)	G6
1 (Q3)	G5
1 (Q4)	G4
1 (Q5)	G3
	1 (G2)
	0 (G1)

3. The values of the remaining cells i.e. G3, G4, G5, G6 and G7 are calculated as the cells G7 and G6 which gives the required solution of the equation.

4 (Q1)	23 (G7)
1 (Q2)	5 (G6)
1 (Q3)	3 (G5)
1 (Q4)	2 (G4)
1 (Q5)	1 (G3)
	1 (G2)
	0 (G1)

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G3= G2xQ5+G1 = 1x1+0 = 1;

G4= G3XQ4+G2 = 1x1+1 = 2;

G5= G4xQ3+G3 = 2x1+1 = 3;

G6= G5xQ2+G4 = 3x1+2 = 5;

G7= G6xQ1+G5 = 5x4+3 = 23

So, the required solution of 60y-13x=1 is (23,5).

Steps of Euclidean Algorithm

Using successive division, the HCF of the coefficient of x and y are calculated. Here, the coefficients are considered to be positive.

60 = 13x4+8 ………….. (I)

13 = 8x1+5……………. (II)

8 = 5x1+3……………… (III)

5 = 3x1+2……………… (IV)

3 = 2x1+1………………. (V)

2 = 1x2+0………………. (VI)

Using successive substitution method, the solution of the equation is calculated.

1 = 3 - 2x1; [From (V)]

1 = 3-(5-3x1) x1; [From (IV)]

1 = 3x2 - 5x1;

1 = (8-5x1) x2 - 5x1; [From (III)]

1 = 8x2 - 5x3;

1= (60 - 13x4) x2 - (13 - 8x1) x3; [From (I) & (II)]

1 = 60x2 - 13x8 - 13x3 + 8x3;

1 = 60x2 - 13x11 + (60 - 13x4) x3; [From (I)]

1 = 60x5 - 13x23

Thus, comparing with the given Diophantine equation we get the required solution as (23,5).

Comparision With Other Ethnomathematical Traditions

Ethnomathematical Traditions	Description and Educational significance
African Counting Systems	It includes indigenous counting systems, geometrical patterns and mathematical practices embedded in cultural life. This system supports the culturally responsive mathematics education (Rosa & Orey, 2016).
Chinese Rod Mathematics	It is a sophisticated indigenous computational method that supports procedural as well as conceptual understanding (Xu & Ball, 2024).
Japanese Soroban Method	It improves mental arithmetic, concentration and computational fluency. It is also associated with the development of algorithmic thinking capabilities among the learners (Lucas & Sanos, 2024)
Vedic Mathematics	It emphasizes fast arithmetic calculation techniques and culturally rooted mathematical learning. Recent studies discuss its role in culturally responsive pedagogy and alternative computational approaches (Rosa et al., 2016)
Kuttaka Method	It is an ancient Indian algorithm for solving linear Diophantine equations. It supports algebraic reasoning, computational thinking as well as culturally responsive mathematics education (Dumka et al., 2025)

FINDINGS AND DISCUSSION

1. Enhances Algorithmic and Computational Thinking: Kuttaka is a method for finding integer solutions to linear Diophantine equations. Its general form is expressed in ultramodern emblematic language and is honoured as a standard system in Hindu mathematics (Shang, 2009; Jain, 2017). Recent work has demonstrated the Kuttaka system step- by- step using Microsoft Excel. This emphasizes its iterative and rule-based characteristic and explains how learners would be able to follow and automate each step, therefore advocating for the development of algorithmic and computational thinking (Dumka et al., 2025). It is noted that algorithmic thinking, decomposition, abstraction, and generalization are the core of computational thinking and mathematics education for the 21st century (Huiyan et al., 2023). Thus, the computational thinking of Kuttaka's equation simplification would also be represented in the same way (Dumka et al., 2025).

2. Conceptual understanding of number theory and equations: Studies on Bhaskara's treatment of linear Diophantine equations show that many Kuttaka problems are simple enough for high school students. Problem-solving approaches to linear Diophantine equations show that this topic encourages exploration of integer arithmetic and the structure of equations. Kuttaka can be another way to delve into these concepts (Dutta, 2010). Reviews of alternative written algorithm teaching strategies suggest that moving beyond mechanical procedures to more flexible and meaningful algorithms improve number sense and reasoning (Lopez et al., 2022). Therefore, Kuttaka can be taught as an understood algorithm rather than just a trick.

3. Alternate method to the Euclidean algorithm: According to Cognitive Load Theory introduced by John Sweller, learning is more effective when teaching methods lower unnecessary mental effort and systematically organize information. In this context, the Kuttaka method can help with math learning through its clear, step-by-step approach to solving linear indeterminate equations. Unlike the lengthy back-substitution methods in the Euclidean algorithm, the Kuttaka's organized steps allow students to track intermediate operations more easily. This reduces extra cognitive load and improves understanding of the process. The method's structured approach may also help students form schemas and boost their problem-solving skills in algebra (Sweller, Ayres, & Kalyuga, 2011).

4. Closeness with other Ethnomathematical Traditions: The Kuttaka method exhibits notable parallels with various recognized ethnomathematical practices, including African numerical systems, Chinese rod-based calculations, Japanese Soroban techniques, and Vedic Mathematics. Similar to these practices, Kuttaka demonstrates culturally grounded mathematical reasoning, structured problem-solving, and algorithmic thought processes. Its historical significance and educational importance reinforce the notion that indigenous mathematical concepts can significantly enhance contemporary mathematics education and culturally attentive teaching methods.

5. Alignment with NEP-2020 priorities: To uplift the strata of mathematics education in India, NEP-2020 focus on conceptual understanding, problem solving, technology integration, and multidisciplinary or culture-rooted learning (Manwani, 2025). Systematic reviews of Computational Thinking (CT) in mathematics call for the embedding of CT (including algorithmic thinking) across school curricula as a foundational competence for the digital age. As such, Kuttaka specifically through Excel or other tools, aligns well with the spirit of this NEP focus on computational as well as problem-solving skills. (Dumka et al, 2025).

6. Astronomical relevance as STEM integration: Kuttaka has direct astronomical applications that can be meaningfully integrated into STEM education today. Bhaskara I's 7th-century commentary on the Aryabhatiya includes 91 verses that solve linear indeterminate equations using astral parameters, computing the number of civil days and revolutions since the beginning of Kali Yuga from mean positions of the Sun, Moon, planetary longitudes, lunar node, apogee and anomaly (Keller, 2014). In a modern STEM classroom, students can study such equations as models of orbital periods and calendar design, then implement generalized matrix Kuttaka on computers or calculators to obtain all positive integer solutions of Sulbasutra-type equations (Sindhurani & Nampoori, 2019). This simultaneously develops algebraic and number-theoretic concepts, algorithmic thinking, and an appreciation of how ancient Indian astronomers used discrete mathematics to solve real scientific problems.

7. Cultural relevance and Indian Knowledge Systems (IKS): Kuttaka is one of three key Indian methods for solving indeterminate equations, along with bhāvanā and cakravāla. These methods are part of a rich tradition in algebra and astronomy (Jain, 2017). The comparative study on integration of Ancient Indian Knowledge Systems with School Curriculum indicates that incorporation of methods associated with IKS help students to complete exercises with more speed, accuracy and enthusiasm (Ibrahim et al., 2025). Ethno-realistic and ethnic knowledge tell us that putting mathematics into the cultural background of learners places them in a much better position for thought and understanding. There is a call for curricula and materials that are responsive to cultural backgrounds (Putri et al., 2025). Therefore, Kuttaka serves as a strong example for Indian contexts in this respect.

SUGGESTIONS AND RECOMMENDATIONS

1. The Kuttaka Method should be introduced in secondary mathematics curriculum while teaching linear equations and concepts related to number theory.

2. Curriculum developers should explore the possibilities of incorporating more methods from Indian roots into the modern mathematics curriculum.

3. Teachers should be properly trained on the pedagogical use of ancient Indian techniques and embrace those methods as an alternative to the modern methods.

4. Educational institutions should encourage interdisciplinary learning by connecting mathematics with the history of astronomy and Indian Scientific traditions.

5. Schools should encourage mathematics club and project activities based on the Indian Knowledge System.

IMPLEMENTATION CHALLENGES

1. Rigid & Exam-Oriented Curriculum: The educational system in India primarily emphasizes examinations. Both educators and students concentrate on finishing the set curriculum and getting ready for board exams. Since Kuttaka is typically not part of many examination structures, it can be viewed as supplementary or non-critical material. Due to time constraints, teachers might refrain from using different historical approaches, even when they could improve conceptual comprehension.

2. Teacher Workload and Time Constraints: Secondary school teachers already have a number of tasks to juggle: teaching, assessing, administration work and extracurricular activities. Kuttaka requires extra preparation, historical context, and hands-on teaching methods. Without institutional support and sufficient classroom time, teachers may view its inclusion as an additional burden.

3. Lack of IKS Training in Teacher Education: Most B.Ed. and teacher education programmes provide very limited exposure to Indian Knowledge Systems (IKS), history of mathematics, or ethnomathematics. Consequently, many mathematics teachers are unfamiliar with the Kuttaka method and may lack confidence in teaching it effectively.

4. Slow Textbook Revision Process: Curriculum and textbook reforms are slow as they require policy approval, expert review and coordination between educational boards. While the National Education Policy 2020 India advocates the inclusion of Indian knowledge traditions, it will take a long time for practical integration in textbooks and classroom materials.

5. Resistance to change: Resistance to change is a major barrier in integrating the Kuttaka method into secondary mathematics curriculum. Many educators prefer traditional teaching methods which focuses on examination performance and syllabus completion rather than integrating new techniques and methods which is seen as an additional burden to them.

LIMITATIONS OF THE STUDY

Despite its insights, this study has several limitations:

1. The study is largely dependent on secondary sources of data. As the interpretations are based on existing literatures, the findings may be affected by the biasness of the previous researchers.

2. The present study is primarily theoretical and review based. The lack of empirical evidences and limited peer-reviewed sources in previous literatures on Kuttaka method makes the interpretations fragile.

3. The study mainly centres around the pedagogical potentials of Kuttaka in Indian Mathematics education system and curricula.

4. The study does not account for examining the practical implementation of the Kuttaka method and its challenges on classroom implications.

5. There is a lack of contemporary educational research specifically focused on the Kuttaka method and its pedagogical applications.

SCOPE FOR FURTHER STUDIES

1. A comparative studies maybe conducted between Kuttaka method and other modern algebraic methods for solving Diophantine equations.

2. An experimental study can be conducted to examine the effectiveness of teaching the Kuttaka method at the secondary school level.

3. Further studies can investigate the pedagogical implications of the Kuttaka method.

4. Researchers may explore students’ attitude and achievement after integrating Kuttaka method in the curriculum.

CONCLUSION

The reviewed literature highlights that the Kuttaka method is both historically important and a strong algorithm for linear Diophantine equations. It is also a useful resource for modern education. Recent research reformulates Kuttaka into matrix and determinant form and extends it to linear indeterminate equations in (n) variables, yielding all positive integral solutions for Sulbasutra-type problems and revealing its deep algorithmic structure (Sindhurani2019; Shang2009; Dumka2025).

The contemporary studies on Vedic/IKS methods and Diophantine equations show that algorithm from ancient times can improve efficiency, engagement and problem-solving in mathematics education (Thakkar2025; Ibrahim2025; Amorim2020) as well as enriches teachers' content knowledge in teaching Mathematics. Hence, all the above findings validate Kuttaka being introduced in secondary school mathematics curricula as a culturally based practice connecting numbers theory with algorithmic thinking and Indian knowledge system.

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