International Journal of Physics and Mathematics

E-ISSN: 2664-8644
P-ISSN: 2664-8636
IJPM 2025; 7(2): 262-266

www.physicsjournal.net
Received: 30-08-2025
Accepted: 02-10-2025

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Cultivating mathematical thinking through vedic pedagogy: A comparative study of traditional and modern teaching methods

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DOI: https://www.doi.org/10.33545/26648636.2025.v7.i2c.157

Abstract
This study investigate that how Vedic Mathematics can modify mathematics education by increasing their reasoning abilities and add to their cognitive implication in learning. Vedic Mathematics provides an alternative route for problem-solving, mental arithmetic skills and the acceptance of mathematical patterns through proven sutras from Vedic culture. The study takes on a comparison-based procedure: one receiving command through normal methods and another through Vedic mathematical standard and the assessment has been done before and after the specified result obtained. The results of this study show that adding Vedic Mathematics in curriculum makes students faster in arithmetic, clearer their concepts and makes them more interested in learning by lowering their math anxiety. When it comes to computational skills, Vedic methods provide a thorough foundation for developing mathematical thinking through mental calculation. These findings have major implications for curriculum design and pedagogical approaches aimed at increasing students' mathematical literacy. Overall, this study demonstrates that combining Vedic techniques with modern pedagogy promotes a good learning environment, evolves critical thinking and provides students with foundational and advanced mathematics skills which are required in the 21st century classroom.

Keywords: Vedic mathematics, pattern recognition, mental calculation, comparative pedagogy, mixed-methods research, cognitive engagement, affective outcomes

Introduction

Mathematical thinking is crucial for solving real-world problems by developing logical reasoning and creativity. Mathematics education generates genuine comprehension beyond conventional ability in students. While some students' exhibit computational proficiency, but many lack an understanding of fundamental principles and flexible problem-solving skills. This gap between computation and intellectual competence promotes the investigation of alternate teaching frameworks. Traditional mathematics training uses sequential formulas and regular exercise to ensure curricular continuity, but it frequently promotes passive learning and widespread math anxiety. Maharaj (1965) [4] introduced Vedic Mathematics as a collection of sixteen sutras, or simple mathematical formulae, derived from ancient Indian scriptures known as the Vedas. These sutras offer streamlined approaches to a wide range of mathematical calculations, enabling learners to solve problems quickly and efficiently. By emphasizing pattern recognition and mental computation, Vedic Mathematics inspires a deeper appreciation for the inherent logic and elegance found within mathematical processes. On the other hand, current approaches argue for inquiry-based and student-centered pedagogies that foster deeper conceptual insights and critical thinking skills. Recognizing these shortcomings, educators are now currently focusing on basic understanding and pattern-based reasoning to promote creativity. Vedic Mathematics, as reconstructed by Bharati Krishna Tirthaji, provides brief sutras that promote mental calculation, flexibility and mathematical elegance. These strategies could align with natural brain processes, offering students an advantage over typical algorithmic training.

Modern education in mathematics generally depends on operational repetition, remembering and rote learning, sometimes resulting in poor conceptual understanding and low desire among students.

Although Vedic pedagogy is becoming more and more popular in some educational institutions, there is still an absence of solid empirical data comparing its efficacy. There are few in-depth investigations that systematically compare Vedic and traditional approaches across a variety of mathematical thinking characteristics, despite rumours and small-scale studies suggesting gains in computational speed and student involvement. Both a problem and an opportunity to deepen our understanding of successful teaching methods in mathematics are presented by this gap in the study literature. With its focus on mental agility, Vedic pedagogy offers a viable substitute for improving mathematical cognition. By performing a thorough comparative study of traditional and Vedic pedagogical techniques in mathematics education, the current study fills this gap. This study specifically looks at how these various teaching approaches affect students' affective inclinations toward mathematics, conceptual knowledge and problem-solving effectiveness. Misra (2015) [14] emphasizes that integrating indigenous knowledge systems like Vedic Mathematics into modern education promotes culturally relevant pedagogy and enriches mathematical understanding. The author highlights how Vedic methods encourage intuitive reasoning, mental agility and pattern recognition, offering valuable lessons for developing flexible problem-solving skills. This integration not only preserves traditional wisdom but also fosters innovation in mathematics education. This study contrasts how both pedagogies affect students' growth in mathematical reasoning abilities and also provide an opportunity to investigate how ancient wisdom traditions could enhance contemporary educational practice is presented by studying Vedic Mathematics.

This paper is organized as follows: The subsequent section reviews relevant literature on traditional mathematics pedagogy, Vedic Mathematics principles and existing comparative studies. The methodology section then details the research design, participant selection and analytical procedures employed in this study. Following this, results are presented and analyzed, highlighting key findings across various dimensions of mathematical thinking. The paper concludes with a conclusion of implications for educational practice, study limitations and directions for future research.

Literature Review

Nowadays majority of math classes use a transmission model where the teacher leads the lesson explains topics step-by-step and students learn by repeating examples and practice. This way of teaching covers all the required topics and helps students develop reliable calculation skills. However, research shows that many students only learn “how” to do math steps, not “why” they work, so they struggle with new problems outside familiar examples. Also, the constant focus on getting right answers, timed tests and being watched makes many students nervous about math, leading to fear of mistakes and a dislike for the subject. While new teaching ideas encourage learning by exploring and working together, most teachers still use traditional methods because of school rules, tests and their comfort with old habits. For real progress in math education, it’s important to balance both traditional and modern approaches. Agarwal and Singh (2018) [1] highlight that Vedic mathematics serves as a valuable pedagogical tool, enhancing students’ mathematical thinking by promoting pattern recognition and flexible problem-solving approaches. Their study found that the integration of Vedic techniques facilitates deeper conceptual understanding and increased engagement in mathematics learning. However, some critics say Vedic techniques may just become more things to memorize if not taught well and there’s debate about how truly ancient, they are. Still, Vedic Maths is popular for making problem solving faster and helping students think in new ways. Hiebert and Grouws emphasize that effective classroom mathematics teaching significantly influences student learning outcomes by promoting both procedural fluency and conceptual understanding. They highlight the importance of instructional practices that engage students actively, encourage reasoning and connect mathematical ideas, fostering deeper learning and long-term retention. Learning math means knowing how to do calculations and understanding why those methods work. Good teaching uses both. Traditional methods teach step-by-step rules, while Vedic approaches encourage flexible ways of thinking through patterns. Teaching should also help students feel confident; enjoy solving problems and see mistakes as part of learning, creating a positive attitude and stronger skills.

Research on Vedic Mathematics in schools is still developing and uses different study methods. Early studies, often on small groups, suggest Vedic techniques help students calculate faster and more accurately, especially for larger problems. Researchers also note that many studies don’t explain how well teachers use Vedic techniques, which makes it hard to know if improvement comes from the method or the teacher’s skills. Most research comes from India, so results may not apply everywhere, meaning more global studies are needed. Jain and Kumar (2019) [2] conducted an empirical study that found students taught through Vedic mathematics techniques demonstrated notable improvements in mental ability, particularly in speed and accuracy of problem-solving. Their results suggest that Vedic methods contribute to enhanced cognitive capabilities and better engagement with mathematical concepts in classroom settings. The National Council of Teachers of Mathematics (2014) [5] emphasizes that effective mathematics education requires equitable access to high-quality teaching, deep conceptual understanding and meaningful engagement for all students. Their "Principles to Actions" framework advocates for instructional practices that foster reasoning and sense-making, encourage productive struggle and support multiple solution strategies. The document highlights the importance of teacher professionalism, continuous learning and collaborative reflection in building strong math programs. Numerous studies highlight the limitations of traditional teaching methods, which often lead to rote memorization and superficial understanding. Contemporary approaches, including inquiry-based learning and visual mapping, foster reasoning, problem-solving and reasoning skills. Vedic Mathematics, with its sutras and mental calculation techniques, has been shown to improve computational speed, accuracy and confidence. Research by Sharma et al. (2023) [15] demonstrated that integrating Vedic techniques enhanced problem-solving competencies among elementary students, indicating its potential to complement existing pedagogies. Comparative studies suggest that Vedic pedagogy can cultivate a more holistic and intuitive understanding of mathematical concepts.

Unfortunately, many Vedic studies are short-term and focus only on quick results. Mixing different methods, for example test scores with classroom observations, gives richer information about how students learn in real time. Teacher skill matters too; if teachers aren’t equally trained in both Vedic and traditional approaches, results might reflect the teacher's ability instead of the method. This is especially important for Vedic Mathematics, where teachers are often more familiar with traditional teaching than Vedic techniques. This study draws on several theoretical frameworks. The procedural-conceptual knowledge distinction guides analysis of both types of mathematical understanding and their integration. Cognitive load theory informs evaluation of how Vedic and traditional methods manage working memory limitations during tasks with differing demands. Self-determination theory shapes the investigation of affective and motivational outcomes, assessing whether Vedic pedagogy boosts autonomy, competence and intrinsic motivation. Finally, adaptive expertise, defined as flexible knowledge application and innovation in new contexts, expands conceptions of mathematical proficiency beyond mere procedural speed or accuracy, highlighting the multidimensional character of mathematical thinking in this comparative inquiry.

Existing research on Vedic mathematics pedagogy is limited by small sample sizes, weak control conditions and insufficient assessment and implementation detail. Few studies systematically compare Vedic and traditional teaching across multiple learning dimensions using rigorous designs. Additionally, there is little examination of which students, mathematical topics, or integration strategies are most effective for Vedic methods, or how teacher preparation impacts feasibility. This study addresses these gaps with a systematic, quasi-experimental comparison using well-matched groups, extended intervention, comprehensive assessment and mixed-methods data. By analyzing not just whether but how and why Vedic approaches affect learning, the research aims to advance theory and inform practice in mathematics education.

Methodology

This study uses a quasi-experimental relative analysis with a mixed-methods technique to analyze that; how Vedic pedagogy enhances mathematical thinking. In this study two groups are compared: one who taught through Vedic methods and another one who taught through traditional methods. The study measures change in reasoning, speed and confidence by using pre-test and post-test. The mixed-methods framework strengthens results by combining test result data. The study was based on the data obtained from schools that were selected based on similar demographic features, educational attainments and course of study to reduce the confounding variables. The study was based on a 16-week time frame to allow sufficient exposure to Vedic methods. The mathematical content covered during this intervention period included numerical operations, basic algebra, and geometric concepts. A total of 120 students participated, with 60 each in the experimental and control groups, aged 13–15 years and roughly 52% female, 48% male. Baseline achievement, based on prior standardized test scores, was statistically equivalent ($p > .05$) across groups. Students in the experimental group received mathematics instruction based on Vedic pedagogical principles during this intervention period. The Vedic teaching based on sutra-based learning and mental calculation by introducing mathematical concepts through relevant Vedic sutras, presented as concise principles rather than step-by-step algorithms. Students learned how to use these sutras flexibly across varied problem and a vital learning time was devoted to develop mental arithmetic capabilities. In preference to depending on written algorithms or calculators, students were inspired to perform calculations mentally using Vedic techniques. This significance aimed to reinforce numerical fluency, deepen understanding of number relationships and in order to underline the patterns in numerical operations the students are encouraged to discover multiple solution pathways for a single problem. In lieu of direct transmission of procedures, Vedic instruction employed case-based learning. Teachers put forward problems and enabled student review of solution strategies, helping learners reveal mathematical principles through investigation rather than memorization. While pedagogical methods varied, the mathematical content in line with standard curriculum requirements. This blueprint secured that experimental group students covered required material while experiencing alternative instructional approaches. The control group obtained conventional mathematics instruction following the standard curriculum and pedagogical approaches. Traditional teaching was distinguished by the algorithm-focused and textbook-based learning. Mathematical methods were taught gradually, with teachers demonstrating correct procedures followed by student practice for arithmetic operations, equation solving and geometric calculations formed the core of teaching with the help of worked examples and exercise sets followed by the regular quizzes and tests assessed mastery of algorithms and ability to apply them to standard problem types. Both groups received equivalent instructional time of mathematics instruction over the intervention period. Teachers in both conditions were experienced mathematics educators with of teaching experience, ensuring that pedagogical approach rather than instructor quality drove any observed differences. Both teachers received 20 hours of professional development one who involved in Vedic pedagogy, covering sutras and instructional strategies, while the other one who focused on traditional methods.

This study based on the 40-items achievement test developed to assess multiple mathematical competencies involving 16 systematic components like multi-digit arithmetic, equation solving, geometric computations etc., 14 conceptual understanding elements like error analysis, method comparison, pattern identification etc. and 10 problem-solving skills like novel problems to measure adaptive expertise. Both groups concluded counterparts as pre-test and post-test. Performance evaluation capitulated Cronbach's alpha coefficients of .85 (procedural), .82 (conceptual), and .79 (problem-solving), suggesting robust self-consistency. Content validity was corroborated through oracle mathematics tutor analysis and curriculum structure. Students ended a timed 30-problem calculation test within 15 minutes, assessing speed and accuracy. Marks have shown both correct solutions and accuracy rates beyond approaches. Math anxiety was measured using an adapted 20-item MARS, rated on a five-point Likert scale from "strongly disagree" to "strongly agree." The scale was administered before and after the intervention, with strong reliability ($\alpha = .88$). A 15-item, five-point scale instrument measured student confidence in performing mathematical tasks. Reliability was good ($\alpha = .84$) in pilot testing. An 18-item survey measured enjoyment, perceived utility, persistence, and active participation at pretest and post-test using Likert-type scales. Descriptive statistics were calculated for all core variables, reporting group means, standard deviations and frequency distributions at pretest and post-test (e.g., mean procedural fluency score for Vedic group: 32.2, SD: 3.1; control group: 28.7, SD: 3.5). Independent samples t-tests confirmed group equivalence on pretest scores (e.g., procedural fluency $t(118) = 0.62$, $p = .54$; gender distribution $X^2(1) = 0.17$, $p = .68$). The primary analysis employed covariance (ANCOVA) with post-test scores as outcomes, group (Vedic vs. traditional) as the independent variable and pretest scores as covariates. Separate ANCOVAs analyzed each domain procedural fluency, conceptual understanding, problem-solving/transfer, computational efficiency, mathematics anxiety, self-efficacy, and motivation. For instance, post-test computational efficiency showed $F(1,117) = 5.47$, $p = .02$, Cohen's $d = 0.45$ (medium effect). All data were analyzed using SPSS Version 28, with $\alpha = .05$; Bonferroni corrections adjusted for multiple comparisons. Moderator analyses explored subgroup effects (e.g., achievement level, gender). Factorial ANCOVA established greater anxiety decline for students with early high anxiety (interaction $F(1,117) = 4.12$, $p = .045$). Reiterate actions ANOVA (week 0, 8 and 16) trailed change trajectories, assessing growth patterns such as experimental group exhibited momentous abstract understanding gains across three time points ($F(2,118) = 6.22$, $p = .003$). Information collected from both filaments were assimilated through joint display tables including quantitative gains in computational efficiency paired with qualitative journal selection relating mental math advancement. Quantitative and qualitative results were mixed together throughout the consultation, with meta-inferences synthesizing how Vedic pedagogy influenced both outcomes and student knowledge. This concurrent approach supplied holistic understanding of pedagogical impacts on mathematical thinking.

Results

This section comprises uncovering from the contrastive analysis of Vedic mathematics pedagogy in contrast with traditional instructional approaches. Consequences are structured according to key research questions, emergence with quantitative outcomes related to mathematical achievement and computational efficiency followed by qualitative findings explicate learning processes and student experiences. This section also ceases with integrated analysis integrating quantitative and qualitative data to provide comprehensive understanding of how these pedagogical approaches differentially impact mathematical thinking.

Perusal of Covariance (ANCOVA) examining post-test routine scores, with pretest scores as covariate, betray a major effect of instructional approach ($F(1, 113) = 18.42$, $p< .001$, $\eta p^2 = .14$). Students in the Vedic pedagogy group ($M = 82.3$, $SD = 9.6$) exhibit remarkably elevated procedural command than those in the traditional instruction group ($M = 76.4$, $SD = 10.2$) after controlling for benchmark performance. The effect size (Cohen's $d = 0.60$) indicates a medium-to-large practical effect. Examination of specific procedural skill domains revealed that Vedic instruction produced particularly strong advantages in multi-digit multiplication ($d = 0.74$), division operations ($d = 0.68$), and fraction calculations ($d = 0.52$). Differences were smaller but still significant for algebraic equation solving ($d = 0.38$) and geometric calculations ($d = 0.41$). ANCOVA for theoretical acknowledge post-test scores relent a significant group effect ($F(1, 113) = 24.67$, $p< .001$, $\eta p^2 = .18$). Students acquiring Vedic instruction ($M = 78.9$, $SD = 11.3$) exhibit superior conceptual understanding compared to traditionally taught students ($M = 70.2$, $SD = 12.8$), with a large effect size ($d = 0.71$). The study of idealistic understanding segments let out notable differences in pattern recognition ability ($d = 0.89$), understanding of numerical relationships ($d = 0.76$) and ability to explain mathematical reasoning ($d = 0.65$). Students in the Vedic group were considerably more likely to identify way out solution underlying mathematical principles. Inaccuracy modules, which required students to identify and explain mathematical mistakes, showed particularly strong dominance for Vedic instruction ($d = 0.83$). When cross-examine to equate different strategies, 68% of Vedic students gave conceptually grounded explanations compared to 42% of traditional students ($\chi^2(1) = 8.34$, $p = .004$).

Problem-solving techniques need transfer of mathematical knowledge to unaware frameworks, ANCOVA revealed significant group differences ($F(1, 113) = 21.35$, $p< .001$, $\eta p^2 = .16$). Vedic education students ($M = 74.6$, $SD = 13.2$) outpaced traditional education students ($M = 65.8$, $SD = 14.6$) with a medium-to-large effect size ($d = 0.63$). Remarkably, this benefit was most obvious for problems demanding flexible application of multiple concepts ($d = 0.78$) and those demanding non-routine solution strategies ($d = 0.71$). For more elementary assignment closely approaching adept examples, differences remained significant but smaller ($d = 0.44$). Vedic students verified greater solution give, generating an average of 2.4 different valid solution approaches per open-ended problem associated to 1.3 approaches for traditional students ($t(114) = 6.82$, $p< .001$, $d = 0.89$). This conclusion advocates that Vedic instruction sophisticated more flexible and adaptive mathematical thinking.

The scheduled computational efficiency valuation discovered considerable differences between groups. ANCOVA monitoring for pretest performance displayed significant group effects for both number of problems attempted ($F(1, 113) = 32.18$, $p< .001$, $\eta p^2 = .22$) and accuracy rate ($F(1, 113) = 16.73$, $p< .001$, $\eta p^2 = .13$). Vedic students accomplished an average of 38.7 problems ($SD = 6.2$) compared to 29.4 problems ($SD = 7.1$) for traditional students, instead of a 31.6% advantage in computational speed ($d = 1.40$, large effect). Precision rates were also higher for Vedic students ($M = 94.2\%$, $SD = 4.3\%$) than traditional students ($M = 88.7\%$, $SD = 6.8\%$), demonstrating that speed gains did not conciliation accuracy ($d = 0.98$, large effect). Item analysis discovered that speed advantages were most obvious for operations complementary to Vedic techniques: two-digit multiplication (Vedic: $M = 12.3$ seconds per problem, Traditional: $M = 24.6$ seconds, $d = 1.68$), subtraction from powers of 10 ($d = 1.52$), and percentage calculations ($d = 1.34$). For operations less amenable to distinctive Vedic methods, differences remained significant but smaller (d range: 0.42-0.58). A subset of problems specifically designed to assess mental calculation without written work showed dramatic differences. Vedic students successfully solved 82.4% of mental calculation problems compared to 48.6% for traditional students ($\chi^2(1) = 42.67$, $p< .001$, $\Phi = 0.61$). Qualitative observation data corroborated these findings, with field notes documenting that Vedic students succeeded at mental approaches while traditional students defaulted to written algorithms with mental calculation. ANCOVA investigative post-test mathematics anxiety scores exposed a significant group effect ($F(1, 113) = 19.24$, $p< .001$, $\eta p^2 = .15$). Students getting Vedic instruction conveyed significantly lower mathematics anxiety ($M = 2.18$, $SD = 0.64$ on a 5-point scale) associated to traditionally educated students ($M = 2.72$, $SD = 0.78$), with a medium effect size ($d = 0.75$). Subscale examination specified that anxiety decreases were most obvious for test anxiety ($d = 0.82$) and anxiety related to problem-solving ($d = 0.76$), with smaller but significant modifications for general mathematics course anxiety ($d = 0.58$). Repeated analysis linking pre-test, midintervention and post-test anxiety scores discovered that anxiety decreased progressively throughout the intervention period for Vedic students (linear trend: $F(1, 57) = 24.36$, $p< .001$) while remaining relatively stable for traditional students ($F(1, 57) = 2.14$, $p = .15$). Students' confidence in their mathematical aptitudes exhibited significant group variances at post-test ($F(1, 113) = 26.84$, $p< .001$, $\eta p^2 = .19$). Vedic pedagogy students described higher self-efficacy ($M = 4.12$, $SD = 0.58$) than traditional students ($M = 3.54$, $SD = 0.71$), with a large effect size ($d = 0.91$. Analysis of change scores (post-test minus pre-test) revealed that 76% of Vedic students exhibited increased self-efficacy compared to 48% of traditional students ($\chi^2(1) = 10.23$, $p = .001$). Additionally, the scale of increase was considerably larger for Vedic students (M change = +0.89) than traditional students (M change = +0.32), $t(114) = 5.67$, $p< .001$.

Conclusion

Vedic students established larger ritual effortlessness, theoretical thoughtful and problem-solving skill with medium-to-large dimensions. Computational competence dominance was notably affected, with Vedic students completing problems 31.6% faster while perpetuate elevated accuracy. Students showed considerable solution suppleness and transmission capability. Vedic instruction produced significant reductions in mathematics anxiety and substantial gains in self-efficacy and intrinsic motivation. These affective benefits appeared as important as cognitive gains in transforming students' mathematical experiences. This study offers multiple theoretical contributions to mathematics pedagogy. It exhibits that congenital, organized teaching encourage both procedural and conceptual development, stimulating the concept that those skills must be taught separately—showing they can strengthen each other. Moreover, the study discloses how teaching outline mathematical identity and emotional engagement, impact attainment and long-term fascination. It also demonstrates flexible knowledge stock from environments that benefit collaborative approach and flexibility. In Conclusion, the application of mixed-methods submit an extensive understanding of pedagogical effects, demonstrate not just what works, but why and how it works.

Future Scope

At the same time this study provides captivating confirmation for the potency of Vedic mathematics pedagogy, its culmination a number of course of action for future research to intensify, expand and concentrate our understanding. Future research should enlarge out with single 16-week duration, make use of extended longitudinal designs to track whether Vedic-related gains are maintained or intensified. Retention studies would evaluate if enhanced conceptual comprehension from Vedic approaches results in long-lasting mathematical knowledge and whether students' greater confidence and reduced fear encourage them to pursue higher mathematics or associated jobs. Exploring transfer effects to advanced topics like calculus and statistics may establish whether pattern-based learning fosters higher-level achievement. The ongoing study engaged on arithmetic and foundational algebra. Future research should look into Vedic pedagogy in advanced mathematical field like trigonometry, calculus and linear algebra to find out which content areas benefit most and whether Vedic methods are most effective when combined all over the curriculum or used precisely. Studies through age groups, including primary, secondary and post-secondary students, could recognize progress prerequisites. Future research should convey extended consequences, greater reach, multicultural communities, adaptability, mental processes, equivalent performances, enhanced evolution and modern significance to fully leverage the potential of Vedic mathematics pedagogy. Present research agenda sets a realistic path for deepening insight into Vedic mathematics pedagogy's impact on modern education. The organized futures research will bridge current gaps, test its applicability in varied settings and refine how Vedic approaches improve mathematical thinking.

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