

Enhancing Basic Numeracy Skills: Role of Vedic Mathematics

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ABSTRACT

'Catch the fox' paradigm is not for the school system where every child is striving for the best in developing their basic numeracy in Mathematics and looking up for teaching strategy with affective quality. The purpose of the study was to assess the effectiveness of Vedic mathematics strategy, compared to conventional method to enhance the basic numeracy skills of students at government school of Chandigarh. Study was experimental in nature having pre-test, post-test design. With a random selection of school, Sample of around 140, 7th grade students of age between 11-13 were matched and put under experiment group and control group (70 each) which were further treated by Vedic mathematics and conventional method of teaching respectively. Results through statistical analysis exhibited the significance difference between the mean gain scores of students under the entire sub divided categories i.e. below average, average, above average while comparing the control group and experiment group which rejected the null hypothesis. The evident gains in pupil performance displayed the effectiveness of teaching through Vedic mathematics followed by the suggestion for large-scale research study to have better insight of it so that it can be implemented under the mathematics curriculum to improve students' basic mathematics learning.

Keywords: Basic Numeracy skills, Vedic Mathematics, Teaching strategies

Introduction

Functionality and the integrality of system of education lies down in fostering the cognitive, social and emotional skills in the learners to reconcile with today's demanding, changing and unpredictable world. System making every endeavour to help students acquire high quality of education through formal and non- formal structures and procedures that further demands the alignment of all the stake holders: educators, families, policy makers. Prepending the objectivity to above venture, maintaining the standards for foundational skills, building the interest and to intensify the accuracy in Mathematics and its basic numeracy skills, have become the convincible thought these days.

The perusal of data from Ministry of Education tells that the Indian system of school education has grasp one of the largest position in the world with nearly 14.89 lakh schools, more than 95 lakh teachers and nearly 26.52 Crore students of pre-primary grades to the level of higher secondary education from varied socio-economic backgrounds. Visual data shows the school-going students' count has been going up incessantly every year in India, but the learning outcome of foundational skills is not matching the proclivity of the system.

Annual Status of Education Report (ASER) 2022, which captures the nationwide report of enrolment of children and their learning outcomes, administering the comprehensive research, posits that, nationally, for most of the grades, the basic arithmetic levels of children have declined over the year 2018. All India statistics for children in Standard III who can perform at least the subtraction descended from value 28.2% in 2018 to value 25.9% in 2022. The grade V children across India, who can perform division, have also shown the substantially declined picture of achievement i.e. from 27.9% in 2018 to 25.6% in 2022.

Mathematics is one of the major domains in PISA along with language and science assessment. The Program for International Student Assessment (PISA) is an international comparative study of 15-year-old students' performance in reading, mathematics, and science literacy. Mathematics was the prime domain in PISA 2022. In United States 34 % of students were low performers in mathematics literacy, scoring below

proficiency level 2 and that was not significantly different from the OECD average (31%). Under long term trend, in 22 education systems (including the United States), average mathematics literacy scores were lower in 2022 than in 2003. In these education systems, score decreases from 2003 to 2022 ranged from 13 points in Uruguay to 60 points in Finland. Under short term trend, in 42 of the other education systems, average mathematics literacy scores for 15-year-olds were lower in 2022 than in 2018. In these education systems, score decreases from 2018 to 2022 ranged from 6 points in Macau (China) and North Macedonia to 69 points in Albania. Even at the international level the unvarying concern leads to the reform efforts. The same discussion cannot be furthered about India because of the unfortunate withdrawal of India from the PISA participation. But when it participated, almost a decade ago, the results were not very satisfying. India was ranked 73rd among the 74 countries which participated. Be it the reason of unfavourable condition due to Covid pandemic or as many experts say the in capabilities of the prevailing system of education, the operative thought of preparing students to stand and confront this competitive world in every circumstance should not take a backseat.

The same concern was corroborated by the National Council of Teachers of Mathematics, NCTM (the public voice of mathematics education), where the NAEP (National assessment of educational progress) project's results showed the decline in scores in mathematics in grades 4 and 8 by 5 and 8 points respectively in 2022 that challenged the existing policies and practices of learning and teaching of mathematics (Barnes, 2022).

In India, as well, a series of efforts in the direction of improving upon the foundational skills in numeracy, reading and writing have their mention in the National Education Policy (2020) which says that it is imperative to acquire the ability to read, write and perform basic numerical operations as a necessary foundation for all future learning at different level of education and for the lifelong cultural practices. Notable Proposed actions, like National Initiative for Proficiency in Reading with Understanding and Numeracy (NIPUN) Bharat Mission and National Curriculum Framework for Foundational stage, by the Ministry Of Education, comprising of the guidelines for teaching learning material, assessment and pedagogical approaches, teacher capacity building programme, are being fabricated for integrated and deep rooted learning. National Achievement Survey under NCERT, conducted every 3 years to evaluate the children learning competencies and the learning progress by assessing the knowledge under mathematics, science, language, social sciences and environmental studies, as an indicator of efficient working of education system, to step forward with appropriate remedial actions at different levels if needed. Another venture, where one of the state level projects is 'Pathways to Numeracy', a mixed method research funded by UK global challenges research fund, aims to examine the coherence and continuity within the existing national framework related to early mathematics content that suggest the alignment of state level material to national level outcomes. But the concerns persist as the gaps quiet glaring. Need and significance of basic mathematics knowledge as lead to the additional force to put forward the research efforts to foster the basic communication, critical thinking and collaboration of a child's growth with 21st century skills. Educational Psychology exhibiting plethora of research for 'learning' of mathematics clearly because of its relative importance in school curriculum, its cognitive significance in school as well as in daily life, its complexity and difficulty in the learning task leading to the advancement in field to much extent. Still the concern about inadequate preparation of a child for higher education and the potential erosion of mathematics as a school subject have prompted mathematics educators to look into what the whole education process needs to get through for the prospective learning. Research work is being encouraged under many facets of teaching-Learning process of mathematics i.e. pedagogy, teacher/teacher knowledge up gradation, classroom settings, evaluation criteria/Assessment methods, inculcation of technological aspects and so many more.

Foremost among these, teaching strategies has always been placed at prominent position, in influencing students learning during the classroom instructions, keeping the learner at central position (Muema, Mulwa, & Mailu, 2018; Okudan, & Yeşilyurt, 2024; Schroeder, Scott, Tolson, Huang, & Lee, 2007). So, planting some positive addition to on-going efforts by government through policies, projects, surveys, analyses, researches on basic skills in mathematics, the present study orchestrated and implemented the ordered research practice to foster the level of numeracy by using teaching strategy of Vedic mathematics.

Numeracy

Numeracy, mathematical literacy or the basics in mathematics being assessed with the objective or subjective measures, somewhere tells the basic requirement of being capable of extracting and then using the numerical information by an individual when taking some decision in daily life. Basic numeracy or the literacy in mathematics, is not the peculiarity that somebody has or not, in fact is the skill that can be acquired by every individual and furthermore can be used to some lesser or the greater extent that obligates for elucidated concept of it. The intensified focus on 'Numeracy' has led to some meticulous definitions being set out and accepted at international, National and local level too. By keeping in view, the requisite culture and basic needs of survival in the society, the augmented development in the Concept of Numeracy as well as in attainment of the objectives in those defined concepts, are always being accepted with scrutiny.

As cited in Geiger, Goos and Forgasz (2015), the origin of numeracy was attributed by Cock-croft (1982) to the Crowther report (Ministry of Education 1959). In view of this Committee, numeracy was observed as the

'Mirror Image' of literacy where being called as numerate doesn't not only meant to develop competence in basic Mathematical skills but also procuring efficient capacity to produce the purposeful usage of these skills. Later, the Cockcroft Committee in the UK under their published work of 'Mathematics counts (report on the teaching of mathematics in schools, 1982)', stated that a 'numerate' person must possess two attributes: person must have the confidence in dealing with numbers to survive through the mathematical demands in practical life and the proficiency to infer the quantitative information being provided in graphs, table, diagrams, charts, medical reports and in the media (Westwood, 2021).

According to Ministry of Education, Foundational Numeracy means, "the ability to reason and to apply simple numerical concepts in daily life and further these foundation skills are the most reliable predictor of longer-term educational outcomes and personal and economic wellbeing".

The international bodies PISA and PIAAC have provided the definitions of numeracy which have evolved gradually from 2000 to till date. PISA in 2000 defined Numeracy as the individual's capacity to acknowledge the place of Mathematics in the world and to make legitimate decisions and judgement by reflective and engaged citizens as basic for an individual's present and future life (personal, social, occupational), (OECD, 2000). In PISA 2022, mathematics literacy is defined as "students' capacity to formulate, employ, and interpret mathematics in a variety of contexts. It includes reasoning mathematically and using mathematical concepts, procedures, facts, and tools to describe, explain, and predict phenomena" (as cited in Geiger, Goos & Forgasz (2015)).

Within the PIAAC numeracy is defined as "ability to use, apply, interpret and communicate mathematical information". It is basic and an essential skill for an individual covering a wide range of quantitative and mathematical information in their day to day lives. Under their specification the mathematical ideas and information is viewed as a parallel skill to literacy.

The above stated measures of numeracy have clearly shown its need and the significance in an individual's life who is striving to walk in societal frame. But somewhere the broader and deeper meaning added to the numeracy has dissolved the primacy of foundational meaning of basic mathematics i.e. the computational understanding while dealing with numbers which is primary need of a child progress in mathematical learning who feels sacred while come across the basic operations of mathematics (Addition, Subtraction, multiplication, division) that is need to be addressed and further resolved.

Development of Numeracy

Much research aimed at investigating the factors affecting the basic numeracy and the mathematics achievement has been conducted during the past years. Variables such as approaches to the learning, mathematics teacher education, mathematical problem solving, roles of memorisation, teacher student relationship, mathematical engagement, teaching strategies, students attitude, mathematics teacher attitude, mathematical anxiety, have been studied. Among all the different factors which influence the quality of mathematical education, the quality of teaching has always been a significant factor (Bishop, Keitel, Kilpatrick & Leung, 2013).

Johann Friedrich Herbart (1776-1841) who gave the concept of educational teaching, asserted and proved that teaching is the 'Central activity of education'. Grouws (1988) asserts that consideration of instruction quality shouldn't be limited to however, to evaluating specific teaching behaviours. It should include examining "the way class room events fit together to form a meaningful learning situation". According to Lampert (2001), the teacher and student work co-equally creating and understanding the mathematical meaning. This Idea have been seminal, following the various researches those claim that after knowing students' thinking process teachers must develop an interpretive lens of making desired changes in classroom whether those changes are of learning, the learner or the subject matter or the strategy (as cited Grouws, 2006).

Enormous body of research on teaching mathematics literacy has emphasised on teaching style and priorities along with affective quality, to be the responsible factors in schools for development of mathematics numeracy (Hofer & Beckmann, 2009; Tai & Lin, 2015; Tzoahr-Rozen & Kramarski, 2013; Asku & Guzeller, 2016).

Teaching strategies in Teaching Learning process are therefore, one of the indispensable facets that help address the most basic and the ever-evolving needs of learner in class room. Some methods of teaching are more effective for, say memorising the number facts whereas other methods of teaching are more effective for deepening conceptual understanding and still other are sound for acquiring smooth execution of complex procedures. In addition, some methods of teaching might be especially effective for showing gain in the short term whereas other might be better having long term gains with for retaining value (Lester, 2007). So, one can conclude that it is the choice of the teaching strategy that primarily help to develop the sense of understanding of mathematical concept, decided by the learning objective in hand.

Delving into the major efforts to improve numeracy at school level it is useful to reflect back on one of the major project, 'The National Numeracy Strategy' launched in England 1998 and implemented in schools since 1999, is designed to facilitate a sound grounding in mathematics for all primary school pupils. It's Framework for numeracy sets out targets aimed at raising standards of achievement in mathematics

nationally especially providing resources for the effective teaching of mathematics and guidance on planning mathematics lessons (Stephens, 2000).

Another project of School of Education, London called as Effective teachers of numeracy (1997) was aimed at identifying the key factors that facilitated the teachers to put to practice the effective teaching of numeracy at the primary phase of schooling. The sample comprised of 11 schools with 90 teachers and a total of over 2000 students participated in the said project. The findings suggested that factors like the ability to form rich network of connection between different mathematical ideas, being able to select and use strategies that are effective and efficient are required to qualify as 'being numerate' were suggested by highly effective teachers (Askew, Brown, Rhodes, Wiliam & Johnson 1997).

Another notable efforts by the Teacher Education program on early numeracy and literacy implemented by Ministry of Education and Science with support of UNICEF worked with aim of providing teachers with opportunities to acquire knowledge and skills for implementing of quality mathematics instruction and quality literacy instruction to improve students outcomes in early numeracy and literacy in the country of Macedonia. Numeracy program was disseminated to all 350 primary schools in the country. The average results of students in numeracy in 2012 was 22 % points higher than results measured in 2009 Which recommended the need to provide continuous, long term and strengthened support to pre service as well as in-service teachers to reduce the pedagogical ambivalence and to improve the teachers' self confidence in relation to students' achievement. The nation can set forth envisioned goals and put forward the vigorous standards compiling the best research and the projects about whole teaching learning process but guidance to teachers for planning and implementation of Planned instructions for children to get fair knowledge of basic mathematics, to make linkage between basic numeracy, mathematical thinking, and the implementation of both, is fundamental.

Vedic mathematics as dynamic teaching strategy

Vedic mathematics is fundamentally a collection of techniques and methods to run out the basic as well as the higher order calculations with desirable speed and accuracy. Vedic mathematics, a set of 16 sutras and 13 sub sutras (first published on 1965), given by *Bharati Krishna Tirtha Maharaj* who was one of the proponents of spiritual teachings of Vedas, attempts to unearth the brief history of mathematics claiming to have fair disposition towards the method (Dattoli, Licciardi, & Artioli, 2021). The pattern of the world around and the mathematics shows deep harmony through basic concepts, theorems, relationships and principles. Vedic mathematics is an approach which encloses power of mathematical knowledge, practical utility, efficacy and the aesthetic value of the subject into one sphere (Aimo, 2023).

Vedic Mathematics techniques, a method or rules, are easily understood with simple applications, approaching almost all the areas of mathematics i.e. arithmetic, algebra, geometry, trigonometry, integration and differential calculus. Vedic concept shows equal relevance in all aspects of mathematics both at primarily as well as in more sophisticated field of technology (Glover, 2001). This method gives the high speed low power design named as Vedic multiplier for microprocessors and communication applications in computers. The operations performed using Vedic mathematics extricates the computer processors from heavy data storage by improving the computational speed (Kanche, Das, & Singh, 2012). Considering the special application of Vedic mathematics, many of the studies explicated that Vedic multiplier is faster than the booth multiplier and the array multiplier which facilitates the modern signal processing (Kumar & Charishma, 2012; Rawat, Rathore, Goyal, Kala, & Mittal, 2015).

The described methods through sutras help the subject to be kept alive by providing attention to underlying pattern. Once the modus operandi involved in practical application is understood by a child, the problem in hand as well as the procedure ceases to be a difficulty (Tirtha & Agrawala, 1992). Day-ongao and Tan (2022) examined the effectiveness of Vedic mathematics through their research study resulting into improved problem solving abilities in students. Paranjuli, Jha, Acharya and Maskey (2020) put forward their study for analysing the effect of Vedic mathematics on the achievement of students which the findings of increased number of high achievers and decreased number of low achievers. Further, Banda (2023) found through his experimental study and open-ended survey responses of the students that Vedic mathematics facilitated easy understanding of concepts by the students, thereby highlighting the usefulness and the simplicity of the method. Now, the benefits of employing Vedic method are multiple but the paucity of research in the same domain propels the researcher to take the current research endeavour. At the same time establishing the significance of integrating this adaptable strategy in school curriculum to address the raising necessity of improving upon the abysmal state of basic skill of the school students.

Present Study

The aim of the study was to examine the effectiveness of Vedic mathematic, as a teaching strategy on basic numeracy skills of the students.

Hypothesis testing

In present study null hypothesis states that there will be no significance difference between the experimental group and the control group for the mean gain scores in Basic Numeracy Skills test.

Operational Definition

Basic Numeracy: It is considered in the study as simple calculation of addition of numbers, subtraction of numbers, multiplication of numbers and division of numbers with further implications in problem solving.

Design and the Procedure

The research design is an outline of the procedure to conduct an investigation. The present study was experimental in nature that was carried out in an objective and controlled fashion so that the precision is maximised and specific conclusion can be drawn regarding a hypothesis statement. In present study, pre-test/post-test Control group design was employed, systematically manipulating the independent variable i.e. teaching strategy in order to evaluate how this manipulation impacts the dependent variable i.e. Basic Numeracy skills of the student. Participants were assigned to matched pairs on the basis of their scores obtained in GCAT test by Gupta and Singh (2012) and then random assignment of participants was done to experiment and control group. All the students were tested on Basic numeracy Skill test as for pre-test findings in school settings only. Thereafter, Students in Experiment group were being exposed to Vedic Mathematics technique whereas control group was treated with conventional method for same duration and for same content matter in school settings only. Around 40 sessions of 40 minutes each, were conducted in both the groups. Post-test was administered after completion of sessions conducting the same test of basic numeracy skills in both the groups measuring the dependent variable with precision. Performance of experiment and control group was compared using test of statistical significance.

Sampling technique and Participants

Target population for the study was grade 7 students. Sample school was taken from the Government schools of Chandigarh by using random sampling technique with due permission of administration. Further Sample size of around 70 students in experiment group and 70 in control group of class 7 of both the gender with age group of 11-13 was being matched using the GCAT scores of the students fixing following criteria.

Group	Division	Division Criteria GCAT scores
Experiment	Below Average	$x \leq 55$
	Average	$55 < x < 70$
	Above Average	$70 \leq x$
Control	Below Average	$x \leq 55$
	Average	$55 < x < 70$
	Above Average	$70 \leq x$

Instrument used to measure the dependent variable

As a part of rigorous data collection Basic numeracy skill test was used as an instrument to measure the numeracy proficiency before and after the conduction of teaching sessions. This instrument was being designed by the researcher with established content and construct validity by experts. Reliability value of items having suitable inter-correlation was found to be 0.75.

Data Analysis and Results

The term Statistics refers to a set of mathematical procedure for organising, summarising and interpreting information. Inferential Statistical technique of t-test was being used to analyse the collected data.

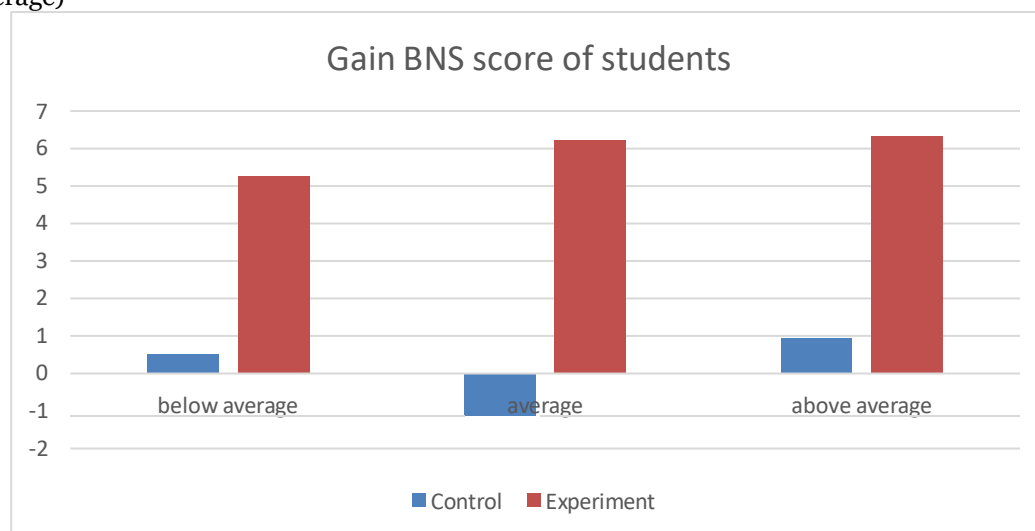
Table1 Mean gain scores for the Control group and Experiment group for: Below Average, Average, Above Average Group of students

Group Statistics						T statistic, p-value
Division	group	N	Mean of gain scores	Std. Deviation	Std. Error Mean	
Below Average	Control	23	.5217	4.32613	.90206	3.739, 0.002
	Experiment	20	5.2500	3.90512	.87321	
Average	Control	21	-1.1429	3.05427	.66650	6.230, 0.001
	Experiment	22	6.2273	4.52434	.96459	
Above Average	Control	20	.9500	4.18613	.93605	3.783, 0.002
	Experiment	22	6.3182	4.93179	1.05146	

Looking into the findings given in Table1, for below average group under the control group (with mean gain of 0.5217, $SD=4.33$) and the experimental group (with mean gain of 5.25, $SD=3.90$), the analysis showed the significant difference in mean gain scores of basic numeracy skills of the students, $t=3.74$, $p<0.05$. Results for

the average group of students under control group (with mean gain=-1.14, SD=3.05) and the experiment group (with mean gain of 6.23, SD=4.52), showed the significant difference in the mean gain with $t=6.23$, $p<0.05$. Further the comparison of above average students under control group (with mean gain= 0.95, SD=4.19) and experiment group (With mean gain of 6.32, SD= 4.93) exhibited the significant different with $t=3.783$, $p<0.05$. so , the null hypothesis ‘ there will be no significant difference between the experimental group and the control group for mean gain scores in Basic Numeracy Skills test’ was being rejected which actually displayed significant change in the performance of the students under experiment group.

Graph representing the mean gain BNS scores of 7th grade students (categorized as below average, average, above average)



Discussion

The purpose of the research was to examine the effectiveness of the Vedic mathematics over the conventional method of teaching for basic numeracy in mathematics for students of grade seven. Results through Statistical analysis exhibited the significance difference between the mean gain scores of students under the entire sub divided categories i.e. below average, average, above average while comparing the control group and experiment group which further depicted that the intervention administered to experiment group displayed the significant change in the performance of all the students under post-test. So, from above findings the Vedic mathematics technique proved to be effective in improving the basic numeracy skills of the students. The present work extended the research findings of Day-ongao and Tan (2022) and Paranjuli, Jha, Acharya and Maskey (2020) who spoke about the positive change in achievement and problem-solving skills of children after implementing the Vedic mathematics technique.

Further the researcher observations and the statistical values for mean gain scores of students under control group also delineated that students' performance did not display the considerable improvement when compared their own pre-test, post-test scoring, in fact the declining picture was observed somewhere under post-test. This necessitated the further conclusion of encompassing some innovative methods of teaching for some specific learning that can pave the way to inculcate interest in students in mathematics. This highlights the fact asserted by Lester (2007) which talks about offering the “effective teaching under condition [x] for learning [y]” suggesting providing the diversified pedagogies which meet the changing requirements of the students' affective aspects. Furthermore, through reflections by experimenter, the observations during class also set forth the improved mathematics performance with increased pace of understanding and computing the numerical problems. Also, the gradual built on the interpretation of problem-based questions and the decision making for the accurate operation to be performed for problem in hand, was observed which added value to the strategy.

Conclusion and Suggestions

The escalating need and the significance of the basic mathematical knowledge in everyday life of an individual, has always led the research to explore the various aspects of its dearth and improvement. Literacy and the numeracy are the prerequisite for the broader Education. Students who struggle to read and perform basic mathematics are more likely to drop out of school before they complete the basic education. So supporting their learning by making effective decisions, after knowing the students, their situations, the content, the teaching strategies, the interaction level and the productivity, is the essential move to marshal the multifaceted act of teaching. Meticulously and continuously developing the concept of numeracy has somewhat make it difficult for teachers as well as for the researchers to figure out how to teach students that

might give the fair chance to children to understand it well. The present study thus aimed at helping the individual in raising their standard of numeracy across their education period. As discussed above this study moved with planned modules of instructions by Vedic mathematics and ended up with quiet glaring evidence of effectiveness of used strategy in improving the basic mathematics skills. The evident gains in pupil performance suggested putting this method under more research work with more scrutiny to have better insight of it so that it can be implemented under the mathematics curriculum across the different age groups in schools to improve their basic mathematics learning. The present research work also explained the broader and richer view of teacher's role to come up with some innovative and effective methods to instruct and explain the basic and advanced mathematics with purpose of encouraging the students to continue with this receptive field and to develop the flexibility in their abilities to accept the new mathematical ideas in some way improving their higher order and critical thinking skills.

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