

VEDIC MATHEMATICS AS A MAESTRO TECHNIQUE FOR SECONDARY SCIENCE LEARNING

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The emergence of new teaching strategies has created the string between the branches of science and their application in a different context. However, Vedic mathematics strategies espoused in science education are sometimes very shaky. This is because adopting and teaching with new strategies makes the facilitator uncomfortable. Sometimes, the facilitator feels insecure about the completion of the syllabus in the given period. However, it would be great if Vedic mathematics collaborated with science to create innovative and creative strategies for teachers in their teaching-learning process, which would make the content more relevant and fruitful for the learners. The present article focuses on integrating Vedic mathematics techniques with science knowledge, especially for the calculations involved in numerical parts of science, which nourish the teaching and learning process in science education. It enables teachers to use integrated Vedic mathematics strategies constructively in their teaching while solving different types of numericals in the science discipline. Vedic mathematics is a powerful technique that allows learners to interact and collaborate with different branches of science, and collaborates as facilitators for mathematical calculations of science. It also facilitates students to apply their knowledge by using diversified strategies of Vedic mathematics techniques in science.

Keywords: Vedic Mathematics, Maestro Techniques and Secondary Science Education

Introduction

“We should not teach children the sciences but give them a taste for them.” — Rousseau.

Vedic mathematics has proven itself as an ever-evolving concept in the last few decades. The *Vedas* and *Upavedas* are a subsequent warehouse of apprehension, which was thoroughly investigated. It was first rediscovered by Jagadguru Sri Bharathi Krishna Thirthaji Maharaja between 1911 and 1918 (Devi, 2021; Joshi, 2017; Karani Prasad, 2016; Kavita, H. Dharmannavar and Smt. Dharmambal, 2015; Kumari, 2014; Moon, 2020; Parajuli, 1997; Rani Shruti,

2015). His work was published in 1965. Vedic mathematics consists of 16 formulae and 13 sub-formulae, called *sutras* and sub-*sutras*, respectively. These formulae represent how the mind works in its natural state. It is expected to considerably assist students in the most appropriate technique of solution (Joshi, 2017). Almost all the mathematical problems can be resolved through the innovative techniques of Vedic mathematics. The beauty of this technique lies in the certitude that it minimises the burden of solving calculations compared to the conventional method of solving mathematical problems (Parajuli, 1997). There would not be any other subject without mathematics

as mathematics is used in every discipline, especially in science. Some of the concepts related to Integrated Science are unfamiliar to the learners since they have not seen or experienced them before, making it harder for them to grasp the inherent concept (Quansah *et al.*, 2011). Several types of research in the field of integrated science education not only took place to enhance knowledge but also skill enhancement among primary and secondary school students.

Modern India has placed a high emphasis on science and technology, realising that it is a critical component for the enhancement of the high achievement of learners through different parameters of knowledge, application and accuracy. The growth of integrated STEM education has been aided by the fields of Science, Technology, Engineering and Mathematics (STEM). It provides a perfect setting for learners to improve their creative thinking, problem-solving, cooperation and communication skills and their interest in STEM areas. As a result, STEM education has been established and included in science education (Sencer Corlu, 2014). It identifies the research contexts and key findings reported in the studies published between 1 January and 28 January 2020. The findings indicate that a significant number of publications consist of reports presented by practitioners, i.e., schools, governmental authorities and educational foundations, and that the tertiary level is the most frequently covered context in the papers. The analysed publications report slightly more Emergency Remote Teaching (ERT). However, integrated STEM with science education

would get more pace if the unique techniques of Vedic mathematics also collaborated with it. Vedic mathematics provides the learner with a broader visualisation and develops concentration abilities in science education. It has been seen that generally, people excel in their knowledge that comprehends the content. At the same time, they find it difficult to prepare solutions with confidence in a very short period, especially when competitive examinations are taken at a large scale. Here, Vedic mathematics provides a solution to the accuracy and confidence about their acquired solutions when content is comprehended perfectly for an individual to excel in science.

Concept of Vedic Mathematics and Science Education

In Indian scripture, there are four incredible scriptures called Vedas, consisting of the *Rig Veda*, *Sam Veda*, *Yajur Veda* and *Athrava Veda*. Every Veda deals with different aspects of knowledge. Among them, knowledge of mathematics comes under *Athrava Veda*, from where some mathematical parts are extracted and rediscovered for society to know the real essence of mathematics. Vedic mathematics was rediscovered by Jagadguru Sri Bharathi Krishna Thirthaji Maharaja between 1911 to 1918 and has given the name to that mathematical calculations as 'Vedic mathematics'. His work as 'Vedic mathematics' came into existence in 1965, in which he illustrated all the 16 *sutras* (formulae) and 13 sub-*sutras* of mathematics and claimed that there are many more things remaining to be discovered from that great scripture.

Sutras and their Translation	
Sutras	Translations
Ekadhikina Purvena	By one more than the previous one
Nikhilam Navatashcaramam Dasatah	All from nine and the last from ten
Urdhva-Tiryagbyham	Vertically and cross-wise
Paraavartya Yojayet	Transpose and apply
Shunyam Saamyasamuccaye	When the sum is the same, that sum is zero
Anurupy Shunyamanyat	If one is in ratio, the other is zero
Sankalana-Vyavakalanabhyam	By addition and by subtraction
Puranapuranabhyam	By completion or non-completion
Chalana-Kalanabhyam	Differential calculus
Yaavadunam	By deficiency
Vyashtisamanstih	Specific and general
Shesanyakena Charamena	Remainders by the last digit
Sopaantyadvayamantyam	The ultimate and twice the penultimate
Ekanyunena Purvena	By one less than the previous one
Gunitasamuchyah	Product of the sum
Gunakasamuchyah	All multipliers

Fig. 1: Vedic Mathematics **Sutras** with their Translation

Science education refers to the percept and investigation of scientific facts and concepts for school children, college students and the general public. Science education encompasses research in science placate, science subpoena (the scientific methods), social science and instructional methodology. Science education not only brings forth expectations among students for their enhancement of learning and proper understanding of content knowledge throughout their learning process from pre-primary to higher secondary but also beyond it. It provides them a base for becoming critical and logical thinkers. It creates a critical understanding of facts, which has been taught to students.

Students should know the background and facts behind any knowledge shared by facilitators in the classroom. Furthermore, the students should critically understand

the relation and basis of any information provided during their classroom transaction. For this, one has to ask questions for genuine understanding, making students more realistic in classroom situations. Probing questions for conceptual clarity shall become the mode of interaction in the science classrooms rather than monotonous presentations through digital screens, which have now become common. Factual understanding can make students more confident in the classroom.

The 21st century is the age of competition where students face many competitive examinations. As a student, one must secure high marks in that particular examination to get admission. The anxiety that usually follows affects one's actual performance in competitive exams. This can be resolved when Vedic mathematics collaborates with science education. Vedic mathematics provides a

system of calculations 10 to 15 times faster than the conventional method of calculation (Kumari, 2014). Vedic mathematics makes it simple, straightforward and direct for all science branches. It helps in understanding the science and enriches their knowledge of the subject. Today's science requires much effort in learning and understanding, especially during the numerical calculations already existing in science. Vedic mathematics provides a system of inspecting the calculation and obtaining the correct results. If we make a habit of applying the effortless and quick checks at different stages of solving calculations involved in numericals, we can move confidently to the next step of the solution after confirming the correctness of the work. Vedic mathematics provides a choice and flexibility at every stage and satisfies the learner with their work. Using Vedic mathematics in science makes the learner more creative, interested and intelligent.

Why Vedic Mathematics for Secondary Science?

At the elementary school level, science is a vast subject that includes physics, chemistry and biology. Regarding student preferences, unlike mathematics or languages, science is unique in nature, so pupils have their preferences in science. Some people despise physics, while others like it; some fear biology, while others excel at it; some struggle with chemistry yet excel at physics. Therefore, it needs to be improved so that every individual likes all the branches of science equally. As we all know, science and mathematics are currently posing numerous problems to teachers and students regarding how they teach and learn. All stakeholders

in education like government, curriculum developers, schools, parents and students are concerned about the rising failure rates in these disciplines. Many countries are observing a decline in students' involvement and performance in science and mathematics (Beauchamp and Parkinson, 2008). Some students believe that failures in science and mathematics are due to the curriculum, while others believe, it is due to inappropriate teaching methods. It is also believed that students' disdain for those disciplines is one of the reasons. According to a Trends in International Mathematics and Science Study (TIMSS) research, global achievement in science and mathematics is declining. To improve science and mathematics learning, teachers must concentrate on the relationship that exists between educational tasks and scientific concepts (Jahreie, 2010). All these issues related to science can be overcome by collaborating the Vedic mathematics strategies within the science concept and their solution because the Vedic mathematics concept can easily be a binding concept for the learners, which seems to be easy, simple, direct and straightforward. It enhances the understanding level of mathematics and enriches the knowledge not only in mathematics but also in other subjects. Nowadays, almost every subject requires a critical understanding of the concept inherent within the subject itself. It makes the subjects and their concepts more relevant, and enhances the confidence and satisfaction level among the students as it provides a simple and quick check at the time of their solutions. One can move confidently to the next level of solution after confirming the correctness of their work.

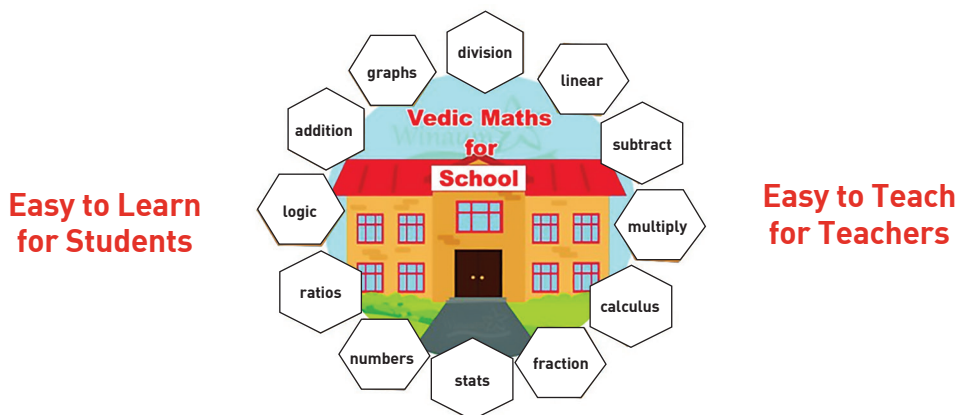


Fig. 2: Vedic Mathematics for School Science

Changing Perspectives of Numerical Calculations in Science

Traditional and linear problem-solving approaches and tools require a significant shift in how individuals think and interact with numerical-based problems in science. One has to spend years putting concepts, techniques and frameworks into practice dating back to the 1960s, 1970s and 1980s. Learners keep doing the same things which they have been doing for the last several decades, using the same tools. It has been used for years and gotten extremely good at it, while in this 21st century, where everything has its own pace, we should adopt different and innovative techniques for solving problems, especially in a science subject. This can be achieved only by integrating the unique strategies and techniques of Vedic mathematics into science. Even today, learners generally use traditional ways of solving numericals in science, which are not up to the mark as the world is changing and setting pace like anything. So there is an urgent need to work smartly to sustain the race. Adaptation of Vedic mathematics

strategies makes the calculation faster and easier. It reduces the time taken by the students for solving numericals. The remaining time can be utilised in some other conceptual questions, which may assure their better rank and numbers in the competitive examinations and their academic performance. This paradigm shift will help the students to become successful citizens of the country and serve the nation with their knowledge. It is an approach to integrating Vedic mathematics strategies in science to enhance the learners' understanding level and development of calculation skills.

Vedic Mathematics Design for Science

A framework is a method of design and development that promotes learning and creativity. It simply gives a set of tools and procedures for resolving issues, directing solutions and creating better experiences. However, the concept of numericals in science seems burdensome for several students. As a result, either the learners leave the calculation part, or if they try to attempt, they are not sure about their answers. This is because of some mathematical issues

such as calculating the roots of an equation, the value of the derivative of a function at a particular location, and the value of the answer of a differential equation at a given position, which exists in fields like physics and chemistry, which cannot be solved analytically. These difficulties give us new possibilities for educational innovations such as intelligent learning environments, which could be smoothly incorporated into our workplace (Freigang *et al.*, 2018). As a result, strategies for obtaining numerical answers to these problems must be devised and implemented. Numerical computations are used to regulate, investigate and build numerical ways to find numerical solutions various problems. It is proposed to provide suitable numerical methods for diverse challenges (Sarboland and Aminataei, 2020).

While introducing chemistry, the concept of Moles can easily be calculated with Vedic mathematics *sutras* named 'Nikhilam' *sutras* (All from IX and the last from X). It can also be solved with the help of *Urdhva-Tiryagbhyam sutras* (Vertically and crosswise), a general formula applicable to all cases of multiplication. Moreover, it is instrumental in dividing a large number by another large number, as it is known that Avogadro's number (6.023×10^{23}) is frequently used to determine the mole concept. Moreover, it makes the whole calculations single-lined and provides accuracy to the learners.

Let us take an example of NCERT textbook of Class XII from the chapter of chemistry.

Q: If the density of methanol is 0.793 kg L^{-1} , what is its volume needed for making 2.5 L of its 0.25 M solution?

Sol.: Molar mass of methanol (CH_3OH) = $(1 \times 12) + (4 \times 1) + (1 \times 16) = 12 + 4 + 16$

By the help of Vedic mathematics of addition, we have,

Addition : Below a multiple of 10

Rule: By completion and non-completion

$$\begin{array}{r} 12 + 4 + 16 \\ = 10 + 2 + 4 + 10 + 6 \\ \hline = 20 + 10 + 2 = 32 \text{ g mol}^{-1} \\ 0.032 \text{ kg mol}^{-1} \end{array}$$

Molarity of methanol solution:

$$m = \frac{n}{v}$$

$$\frac{0.793}{0.032} \text{ kg/mol}$$

By the help of Vedic mathematics of division, we have

$$\begin{array}{r|l} 32 & 7 \ 9 \ 3 \ 0 \\ & 1 \ 3 \ 4 \\ \hline & 24.78 \end{array}$$

Therefore, the molarity of the methanol solution is 24.78 mol L^{-1} .

Since density is mass per unit volume,

$$\text{So, applying } M_1 V_1 = M_2 V_2$$

$$\text{Or, } 24.78 \text{ mol L}^{-1} \times V_1 = 2.5 \text{ L} \times 0.25 \text{ mol L}^{-1}$$

$$\text{Or, } V_1 = 2.5 \text{ L} \times 0.25 \text{ mol L}^{-1} / 24.78 \text{ mol L}^{-1}$$

With the help of Vedic mathematics, square of 25 will be—

$$\begin{array}{r} +1 \quad 2 \quad 5 \\ \swarrow \quad \searrow \\ 25 \quad \text{i.e., } (2+1) \times 2=6 \\ \hline 625 \end{array}$$

$$\text{Or, } V_1 = 0.625 / 24.78 \text{ mol L}^{-1}$$

With the help of Vedic mathematics division, we get 25.22 L.

In physics chapter like Light: Reflection and Refraction of Class X, Vedic mathematics techniques can be used to solve related numerical problems in that chapter. In this particular chapter, the *sutras* like '*Ekadhikena Purvena*' *sutras* [By one more than the previous one] for specific types of numericals, such as calculation of the power of the lens and sometimes, can also be used for determination of mirror and lens formula. Adaptation of Vedic integrated strategies in physics would enhance the understanding level of numericals and also create interest among learners regarding the subject.

Let us take an example of the NCERT textbook of Class X from the chapter of physics — Light: Reflection and Refraction.

Q: A convex mirror used for rear-view in an automobile has a radius of curvature of 3.00 m. If a bus is located at 5.00 m from the mirror, find the position, nature and size of the image.

Sol.: Radius of curvature (R): 3.00 m

Object distance (U): 5.00 m

Image distance (V):?

Height of the object (h_o):?

By using the sign convention of the mirror formula, we have:

The radius of curvature (R): +3.00 m.

Object distance (U): -5.00 m

Focal length (f) = R/2 = +3.00/2 = +1.50 m [as the principal focus of convex mirror is behind the mirror].

According to mirror's formula

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$$

$$\text{Or, } \frac{1}{v} = \frac{1}{f} - \frac{1}{u}$$

$$\text{Or, } \frac{1}{v} = \frac{1}{1.5} - \frac{1}{-5}$$

$$\text{Or, } \frac{1}{v} = \frac{1}{1.5} + \frac{1}{5}$$

Or, Vedic multiplication (multiply a number by 5).

Take any number, depending upon the odd and even nature of the number, divide the number by 2 (get half of the number). In this case, 1.5 is odd, so,

$$1.5 \times 5$$

$$\text{Step 1: } (15 - 1) \div 2 = 7$$

Step 2: As it is an odd number, instead of 0, we will put 5

The answer will be $1.5 \times 5 = 7.5$

$$\text{Or, } \frac{1}{v} = \frac{6.5}{7.5}$$

$$\text{Or, } v = \frac{7.5}{6.5}$$

$$\text{Or, } v = \frac{75}{65}$$

By Vedic mathematics techniques of division, we have—

Here, we have $75 \div 65$.

Step 1: Write the dividend separately.

Step 2: Divisor will be treated as two separate digits.

$$\begin{array}{r|l}
 65 & 7500 \\
 & 114 \\
 \hline
 & 1.15
 \end{array}$$

Or, therefore, $V = 1.15m$

Magnification

$$m = \frac{h_i}{h_o} = \frac{\text{Height of Image}}{\text{Height of Object}}$$

Or, $-1.15/-5.0 = +0.23$

While teaching biology, Vedic mathematics can be used in the Heredity and Evolution chapter to calculate Mendelian ratios and percentages. For this particular chapter, we can use '*Paravrtya Yojayet*' sutras (transpose and adjust) to make the calculations easier and more enjoyable for the learners. It will surely maximise concentration and self-confidence among the students. It will also create interest within the learners for their concerned subject.

Similarly, in biology, one can apply Vedic mathematics strategies for the simple calculation of osmosis concentration and rate for exchange.

Challenges of Teaching Vedic Integrated Science

One of the most challenging tasks for science teachers is to design classes that will not only

motivate students to study but also keep their attention high. What students can relate to the topic that they are studying, is simpler for them to stay on focus. This encourages them to participate in the activity on a personal level. Teachers will be more successful in attracting students' attention, if they are familiar with the topic and enthusiastic about the content, like how we introduce these new and innovative strategies for solving science numericals. However, teachers do not want to take the risk and follow the same traditional way of calculation.

Science learning is an entirely different experience for many teachers than their personal science learning experiences because they taught with the same concept and strategies which they learned in their own time. To the 21st-century learner, it is a quite irrelevant and inappropriate way of dealing with the ever-changing concept of science. Science may not have been about 'doing' as a kid but rather about memorising facts and learning new vocabulary and phrases. As these burdens are already with the learners, there is no need to increase them by using complicated calculations of numericals. So, it would be better to adopt Vedic mathematics integrated strategies for science, which make their learning more appropriate and relevant. The role of teachers is to assist learners in understanding the concepts and enhancing the abilities that they can apply throughout their life, not merely memory data for a single test. Students will benefit from the scientific process skills of classifying, observing, measuring, communicating, inferring, predicting and experimenting not only in science class but also in all circumstances they encounter in life, as educators are encouraging students to acquire higher-order thinking skills in the

development of creative and critical thinking among learners. It will help the learner formulate inquisitive questions, problem-solving, argumentation and other scientific skills. These skills will also help them become modern and active citizens who are scientifically and technologically literate and should begin early in their education.

and workshops on Vedic mathematics strategies so that every individual would know the real essence of Vedic mathematics in their life, either as a teacher or as a learner. It should be introduced as a pre-service and in-service training on Vedic mathematics and Vedic integrated science for teacher and students-teacher.



Fig. 3: The Challenges of Teaching Vedic Integrated Science

Suggestions

It is being suggested by the curriculum designer that Vedic mathematics should be introduced in the early stage of student learning, i.e., it should be introduced in their primary learning stage to enhance the problem-solving skills and understanding of existing concepts within the subjects. The curriculum designer has to organise seminars

It is being suggested that teachers need to be trained on how to use Vedic mathematics for solving numerical problems in teaching science to fulfil their learning objectives. It will help them achieve their goals and objectives of teaching science. Teachers should understand how to formulate a lesson plan for numerical problems in science by involving Vedic mathematics techniques,

which makes the teaching-learning process simple and pre-planned. The facilitators need to update themselves with the techniques of Vedic mathematics *sutras* and sub-*sutras* to understand how they fit into the science curriculum as Vedic mathematics makes learning more simplified and unified than traditional science teaching methods. It is also suggested that teachers should use Vedic mathematics strategies frequently to improve and support calculation and problem-solving skills, which keep the learner motivated and on track. Teachers should participate in teacher-training programmes on courses or workshops on Vedic mathematics strategies for their science classroom so that the knowledge provided by the facilitators keeps the learners' mind alert and alive.

It is being suggested for the students that they have to use *sutras* and sub-*sutras* frequently for solving problems in mathematics in their early stage of learning mathematics which develop the thinking capabilities among learners so that they can correlate it with other subjects of their existing curriculum. Students should practise all the formulae of Vedic mathematics from time-to-time to reduce their fear of calculation and start enjoying solving mathematical and numerical calculations. Moreover, students must try to correlate it with other branches of science except for mathematics to equip themselves with a high level of intelligence, sharpened minds and enhanced mental ability.

Conclusion

The essence of mathematics is not to make simple things complicated but to make complicated things simple. Vedic

mathematics strategies themselves are powerful tools for mathematical calculations for learners. It consists of a total of 29 formulae and sub-formulae, which Thirthaji Maharaja rediscovered. It would be great if Vedic mathematics strategies are collaborated with science education. It would enhance problem-solving skills not only in mathematics but also in science, especially in the numerical part of science. This field looks pretty innovative and provides easy solutions with accuracy to the learners. Vedic mathematics also provides a quick check at the time of their solution, enhancing the satisfaction level of understanding the existing concept among the learners. It would attempt to change the perspective of numerical calculations in science. Vedic mathematics definitely maximises the strength among the learners. Apart from this, it can be seen that new strategies have to face several problems when these come into action. The teaching of Vedic integrated science also has several challenges like — lack of insufficient preparation, reinforcement and future prospective vision of institutions as well as teachers, lack of practices and many more. Nevertheless, all these can be overcome once it has been implemented as Vedic mathematics equips the learners with a high level of intelligence and enhanced mental ability.

Vedic mathematics techniques result in designing many substitutes in use for calculations of numerical problems in science, which thus, unbolt an innovative and creative life for science learning by integrating it with science. Teachers should support the revitalisation of this Vedic integrated science by updating new developing strategies of Vedic mathematics

in science. The study dispenses guidance on using Vedic mathematics strategies as calculation tools for numericals in science during the teaching-learning process. The needs of the 21st century learners are satisfied through the use of Vedic mathematics in the science classroom.

It would be the most appropriate way of teaching science, especially numericals. There is a need for a paradigm shift in a teaching-learning situation through transformational approaches. Hence, Vedic integrated science acts as a maestro technique for science teaching.

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