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Aesthetic appeal and utility of Vedic mathematics: An introduction

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Abstract. Mathematics and aesthetics are closely intertwined. Not only mathematical concepts, relationships and theorems can be aesthetically pleasing, but we also often find harmony between their results and the patterns of the world around us, and we like that. Yet, apart from rare exceptions, the beauty of mathematics, particularly in education, is mostly unrecognized: this science rarely meets the favour of students. Vedic mathematics is an approach which encapsulates the enjoyment and power of this knowledge, not only in the sphere of thought process, but also in its practical utility. It highlights and develops the aesthetic dimension of learning in a very immediate sense. The aim of this article is to introduce the method – what it is and how it works – to give comparative examples of techniques and their efficacy, and to emphasize the aesthetic value it conveys.

Keywords: vedic mathematics, Bharati Krishna Tirtha, aesthetic education, unity, relation.

Mathematics and aesthetics are closely intertwined (Sinclair, Pimm, Higginson [2010]; Breitenbach, Rizza [2018]; Ivanova, French [2020]). Not only mathematical concepts, relationships and theorems can, within themselves, be aesthetically pleasing, but often we also find mathematical results and connections arising through mental reasoning in harmony with the order and patterns found in the world around us, and we like that. Yet, apart from rare exceptions, the beauty of doing mathematics is mostly unrecognised: this science rarely meets the favour of students. Reason is often inherent in the teaching of the discipline which presents it as a pure mechanism, a perfect and complete construction, to which one must submit and in which it is difficult to see the possibility of choice and play, discovery and art: «By concentrating on *what*, and leaving out *why*, mathematics is reduced to an empty shell» and there is no chance for having and developing an individual «mathematical taste» [Lockhart [2009]).

Vedic mathematics is an approach which encapsulates the enjoyment and power of mathematics, not only in the sphere of thought process, but also in its practical utility. It highlights and develops the aesthetic dimension of learning in a very immediate sense enabling even non-professionals to perceive themselves as protagonists in a continuous and creative process of problem-solving. Its characteristics are applicable to primary and high school students, to undergraduate students of STEM subjects and to professions requiring a high degree of mathematical content such as in computer coding, finance, insurance, engineering, scientific research, and the like. The aim of this article is to introduce Vedic mathematics – what it is and how it works – to give comparative examples of techniques and their efficacy, and to emphasise the aesthetic experience it provides, in particular from a pedagogical point of view.

1. ON THE ORIGIN

Sri Bharati Krishna Tirtha (1884-1960) was born in Tinnevely, near Chennai, in Southwest India. Throughout his school and university career he stood out for his memory and brilliant talent in various disciplines: Sanskrit, Philosophy, Mathematics, English, History and Science. In 1911 he retired from teaching to devote himself to spiritual research and advanced study of Vedanta philosophy following the Shankaracarya[1] of Sringeri, in Mysore. This included in-depth studies of ancient Indian mathematics from various published and unpublished resources. In 1925 he himself obtained the position of Shankaracarya, continuing to deepen and teach *Advaita*, a Sanskrit word which simply means «not two» and indicates the essence of ancient Vedic teachings: the philosophy of unity. Before he died, he left an introductory illustrative manuscript to Vedic mathematics which was published posthumously five years later (Bharati Krishna Tirtha [1965]).

At that time, in London, the School of Economic Science – now called School of Philosophy and Economic Science – became deeply involved in learning and understanding *Advaita* and its practical application, and this included Bharati Krishna Tirtha's volume. With reference to mathematics, the Vedic approach draws on both the conscious experience of mathematical activity as well as the objects of mathematical concepts. The effect of this is to reveal the humanising element so that, for example, the experience of calculation is just as important as the result of calculation. This gives a unifying quality to both the objects and the conscious activity, but at the same time it constitutes an overturning of the common Western habits and way of thinking.

Groups of adult teachers and researchers spent many sessions learning the Vedic approach with the aim of understanding and utilising the system. A season of interest and research commenced with Jeremy Pickles, Andrew Nicholas and Kenneth Williams (who runs the online Vedic Maths Academy) and a little later, James Glover (now Chairman of the Institute for the Advancement of Vedic Mathematics). Through exacting study of the Shankaracarya's book, together with studying Advaita philosophy and, most importantly, practising and reflecting on the techniques, those involved began to understand the scope and potency of the approach.

They pointed out that not only does it provide highly efficient and flexible methods, both numerical and algebraic, but also sets out a substratum for mathematical thinking: this underlying way of thinking was expressed by Bharati Krishna Tirtha through a relatively small number of aphorisms or word formulae called *sutras*. They then started promoting its diffusion through manuals (Kenneth [2003], [2005]; Glover [2004-2005]) and joint research projects (Nicholas, Williams, Pickles [2003]; Glover [2016]; IAVM [2017], [2018], [2019]). But above all they concluded that the sutraic approach provides a new paradigm for mathematics; not by asserting new definitions or principles of mathematical objects and their relationships but one that threads together the thought processes involved in mathematical activ-

[1] This is the highest religious rank in Hindu culture, and it belongs to a lineage of philosophers, who, starting with the forefather – Shankara (8th c. CE) – have distinguished themselves in reading and teaching sacred texts, thus earning special status and many followers.

ity: one which humanises the subject recognising its aesthetic nature and which gives a unifying and inspiring orientation[2].

The next sections will proceed to give an initial proof of this, highlighting the centrality of the principle of unity within the methods and at the same time its valorization of multiplicity as reflection and fiction of 1: evidenced through a dynamic relationship between one and many, of which the human being is the main actor. To do so, simple arithmetic examples will be used both to show the effectiveness and distinctiveness of the approach from the very early interactions with numbers and because for most students it is precisely the first access to mathematics that is likely to determine a positive or negative attitude for the continuation of its in-depth study.

The choice of this specific focus responds to the possibility of extending aesthetic research connected to science. As Margherita Arcangeli and Jérôme Dokic pointed out, not only the objects and the products of scientific enquiry may instantiate aesthetic values, but also «the scientific practice (such as constructing and evaluating theories, and designing experiments) may be guided by aesthetic experiences and judgements» (Arcangeli, Dokic [2020]: 104). However, as can be seen from the content of the parenthesis, current research does not devote specific thought or give as much value to the learning process or non-professional activity. The objective of the paper is also to bring attention to them as well and to show how the Vedic approach promotes an aesthetic engagement of the subject.

2. UNITY (AND FLEXIBILITY) OF PROCESS

Vedic mathematics proposes that the human psyche operates through particular patterns of thought processes and that these are not random but due to a natural mental structure. Just as the human body has natural features common to all humans, such as five fingers on each hand, so too does the mind have characteristic ways of thinking common to everyone. Furthermore, these patterns of thought processes are limited in number. The inspiration of Bharati Krishna Tirtha was to identify these processes and express the essence of each in succinct word-formulae (aphorisms) called *sutras.* In Indian philosophy a sutra encapsulates a general or specific principle or a rule or method in as few words as possible. The Sanskrit word itself means «thread» (from we which we have the word *suture*), but specifically a «thread of knowledge».

There are sixteen main sutras or aphorisms and a similar number of sub-sutras in Vedic mathematics. Bharati Krishna Tirtha expressed them in Sanskrit – in order to encapsulate their full meaning – and also gave useful translations in English: «The Sutras are easy to understand, easy to apply and easy to remember; and the whole work can be truthfully summarised in one word "mental"» (Bharati Krishna Tirtha [1965]: XXXVI). The limited number of mental processes, or channels of working, is akin to the restricted number of notes in music. The octave has seven notes and yet the number of possible compositions is endless. So too, many of the sutras have a countless number of applications.

For example, the sutra *Transpose and Adjust* expresses a mental process experienced in many diverse topics – including arithmetic, algebra,

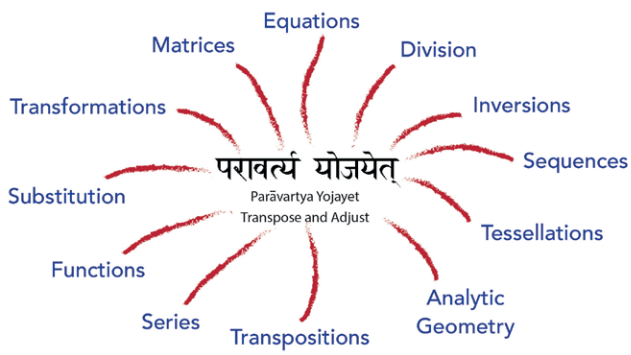

Figure 1

[2] I would like to thank James Glover and Swati Dave from IAVM (https://instavm.org/) for having provided me with first-hand information on the history of Vedic mathematics, for having extensively discussed with me many of the topics here touched upon, and for having granted me permission to use two images whose rights are property of the Institute (see the next section).

geometry, calculus (Bharati Krishna Tirtha [1965]: XXXV) – as illustrated in the Figure 1.

The following examples illustrate similar mental activity which can be expressed through this sutra:

$$\frac{3}{5} \div \frac{2}{3} = \frac{3}{5} \times \frac{3}{2} = \frac{9}{10}$$

The second fraction is transposed and the sign ÷ is replaced with x. A similar process is involved when we find the equation of a perpendicular line. Given one line with equation $4x - 3y = 8$, the perpendicular which passes through the point (5,1), has equation, $3x - 4y = 19$. The x and y coefficients are transposed and the sign between is reversed. Another example occurs when finding the inverse of a square matrix:

Given $\mathbf{A} = \begin{pmatrix} 3 & 5 \\ 2 & 4 \end{pmatrix}$

then $\mathbf{A}^{-1} = \frac{1}{2}\begin{pmatrix} 4 & -5 \\ -2 & 3 \end{pmatrix} = \begin{pmatrix} 2 & -\frac{5}{2} \\ -1 & \frac{3}{2} \end{pmatrix}$

Here, the elements of the leading diagonal are transposed and the elements of the sub-diagonal have their sign changed.

Now, although the mathematical objects and relationships in each of these examples are different, each involves a transposition and some adjustment. There are numerous other instances in mathematics involving unrelated objects but where similar transpositions occur. Since, in each case, the underlying mental process involved is the same they become linked through recognition of the aphorism or sutra (Glover [2018]; Williams [2021]): exactly as happens with the thread of a necklace with which the pearls are strung together and connected to each other. And not only is this aesthetically pleasing but also induces an acceleration of learning and enhances long term memory.

If we then turn the starting focus upside down – from the process to the problem – we notice another characteristic of the Vedic approach: it accepts that any solvable mathematical question can be worked in a number of ways. For example, when facing a simple number problem, such as 45^2, the system invites us to stop and look and not immediately jump into using a *blanket* method since there may well be easier or more enjoyable paths available: the knowledge of the Vedic techniques allows the users to choose whichever method they prefer. This is illustrated in the Figure 2, which mentions the sutras involved in each of the possible methods.

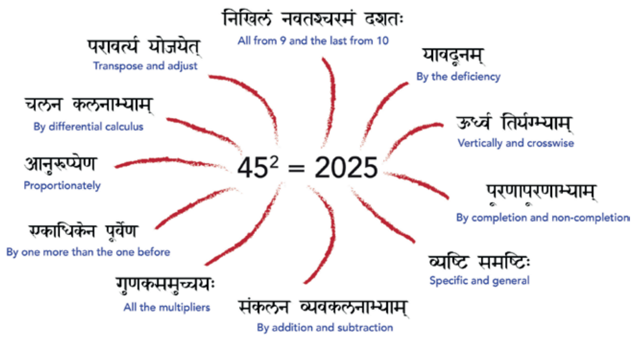

Figure 2

One simple technique applies to squaring numbers ending in 5. The sutra involved is *By one more than the one before*. The method takes the penultimate digit, 4, and multiplies it by one more than itself, $4 \times 5 = 20$. This gives the first two digits of the answer. Final two digits are simply the square of 5, 25. The full answer is then 2025. Another technique uses the principle of the difference of two squares, $a^2 - b^2 = (a + b)(a - b)$, which comes under the sutra *By addition and subtraction*. In this case, $45^2 - 5^2 = (45 + 5)(45 - 5) = 50 \times 4 = 2000$, from which, $45^2 = 2000 + 5^2 = 2025$. With choice of method comes not only the respect and promotion of the subject's attitudes and preferences, but also the development of strategic thinking:

> It is sometimes asked, of what benefit are all these different methods? In respect of education, these methods show that there is more than one way "to skin a cat". Students who learn different techniques understand that different strategies can be used to solve a problem. This is of great use for training in problem solving. In the world of industry and commerce problem-solvers are highly employable. (Glover [2019]: 25)

3. UTILISING UNITY

Another striking feature of Vedic mathematics is how it utilises unity – main theme of Advaita (Glover [2018]) – in arithmetic to make calculations simpler and easier. In terms of pure number, unity is expressed as the number one but also as 10, 100, or any power of ten, since these are just 1 with zeros standing close by. Here is a simple example in calculating 7 x 8.

$$\begin{array}{r} 7 - 3 \\ \times\ 8 - 2 \\ \hline \end{array} \qquad \begin{array}{r} 7 - 3 \\ \times\ 8 - 2 \\ \hline /\ 6 \end{array} \qquad \begin{array}{r} 7 - 3 \\ \times\ 8 - 2 \\ \hline 5\ /\ 6 \end{array}$$

Both numbers are close to 10 and their deficiencies are 3 and 2, respectively. 3 and 2 give the relationship to the unity of 10. The right-hand digit is found by multiplying the two deficiencies, 3 x 2 = 6. The tens digit is found by cross-subtracting, either 7 – 2 or 8 – 3 = 5.

This method can be extended to larger powers of 10, for example 888 x 997. The column method we are familiar with is rather lengthy and prescribes multiplying one digit at the time, producing partial products, and then adding all products together into the final result.

```
    888 x
    997 =
--------
   6216
  79920
 799200
--------
 885336
```

The Vedic method works on the closest base unit, e.g. 1000 – a *reflection* of 1 – computing by excess or by deficiency in relation to it and applying the sutra *All from 9 and the last from 10* – which allows to easily and quickly find the deficiency from a power of ten[3]. In the example above, the deficiency of 888 is, 9 – 8 =1, 9 – 8 = 1 and the last from 10 (10 - 8) = 2, giving 112. For 997 the deficiency is 003. The product of the deficiencies is 112 x 3 = 336. For the left-hand part of the answer, subtract 888 – 003 or 997 – 112, both giving 885.

$$\begin{array}{r} 888 - 112 \\ \times\ 997 - 003 \\ \hline \end{array} \qquad \begin{array}{r} 888 - 112 \\ \times\ 997 - 003 \\ \hline /\ 336 \end{array} \qquad \begin{array}{r} 888 - 112 \\ \times\ 997 - 003 \\ \hline 885\ /\ 336 \end{array}$$

This moving from and going back to the unit, «pretending» (Glover [2018]: 182) that a number is also other than what it appears at first sight, is a common refrain in Vedic mathematics. This principle can in fact be extended far beyond the power of 10, by looking case by case for single entities or whole numbers – another form of recognition and expression of the unity – which can simplify and speed up the calculation.

In order to better understand this point, we can take another multiplication, for instance 298 x 3. The method traditionally taught in school is:

$$\begin{array}{r} 298 \\ \times\quad 3 \\ \hline 8_29_24 \end{array}$$

Working from right to left, multiplications of 8, 9 and 2 are required, together with carry digits. The Vedic approach is first to look at the numbers involved and then see that it is close to 300 x 3. 298 is less by 2. Following this, the answer must be 900 – 6 = 894. Although some students will naturally see this without any help, the Vedic approach teaches this systematically. At the utilitarian level this common urge leads to efficiency and therefore greater productivity. From a philosophical point of view, we can see at play one of the aesthetic factors inherent in scientific practice: *simplicity*. As Catherine Z. Elgin wrote, although

[3] In short, given any whole number multiple of 10 (i.e. one of the first *fictions* of 1), it is possible to easily calculate the result of any number subtracted from it, by finding the difference to 9 for each digit, except the last one, for which the complementary to 10 is calculated. For instance: 10000 – 2895 = 7105.

it is «complicated» to say and define, this criterion functions as «gatekeeper» for the acceptability of a theory – and, we may add, also for the preference of one calculation process over another – because it facilitates «intelligibility or tractability» (Elgin [2020]: 29).

With Vedic mathematics, as illustrated above, there may well be a number of possible and simple strategies that can be used to solve a problem but the skill and the art is to find the method involving the least personal effort and the highest satisfaction: the best «processing fluency at the psychological level» (Arcangeli, Dokic [2020]: 117). In order to better understand how that is possible, it is useful to dig deeper into the aesthetic experience underpinning it.

4. AESTHETIC APPEAL AND EXPERIENCE

«Don't think, but look!» (Wittgenstein [1953]: § 66). The motto included in the *Philosophical Investigations* is loudly echoed by the invitation to «look at the number» which the Vedic mathematics students hear from the first lesson onwards. In fact, included as one of the sutras is the curious statement, *By mere observation*, inviting the student to look first. Its immediate effect is to pin our eyes wide open looking or waiting for something extraordinary to appear. Similar to what happens while staring at *autostereograms*, those bidimensional images usually made of countless colourful dots which are designed to simulate a 3D optical illusion.

In the case of Vedic mathematics, this practice allows the lightening up of an open and alive field of *relations*. Thanks to the teacher's introductory mediation and exemplification, one's intuition is kindled and one's imagination is fired up: breaking up numbers and putting them back together; tracing similarities and enhancing correspondences. One example? Let's take the number 9. One could claim, and grasp, that 9 is 9 – once more the unity and identity principle at play – but one could also claim that 9 is 3 x 3, 4 + 5 or 10 - 1, and so on, to infinity. We then realise that being is said in many ways (Aristotle: M 2 b 15-17), and that, according to the type of problem we face, we take one of its expressions into account rather than the other. We have the opportunity – without necessarily already knowing or having to delve into the classic philosophical problem inherent the intension and extension of a concept – to *pretend* and *turn to act* that one number is other than what it at first seems to be or to appear. It is a basic and creative experience that gradually goes on to expand and deepen.

This explains and clears out one of the most widespread misunderstandings concerning Vedic mathematics, which wants it to have something to do with a handbook of tricks. As he answers the question of whether it is about science or magic, Bharati Krishna Tirtha writes: «It is both. It is magic until you understand it; and it is mathematics thereafter» (Bharati Krishna Tirtha [1965]: XVII). Among the greatest cultural differences separating Eurocentric mathematicians and classical period Indian mathematicians is the fact that the latter solve calculations and algorithms intuitively without needing to provide other justification other than that they work. Nevertheless, the Shankaracarya provides a full exposition of the algebraic structure of the method. A simple example is connected to the already mentioned number 9.

Let's say we divide 1.023.101 by 9. The Vedic method suggests a progressive addition of digits as follows:

1
1 + 0 = 1
1 + 2 = 3
3 +3 = 6
6 + 1 = 7
7 + 0 = 7
7 + 1 = 8

The answer is 113677 with a remainder of 8. This is easy to grasp when a simpler case is taken, such as 34 ÷ 9. Here the result is 3 with a remainder of 7 because 9 is one unit less than 10. For each 10 in the tens column, there will then be a 9 with a remainder of 1. For three tens there will therefore be 3 amounts of 9 and a remainder of 3 which adds to the original 4 units in the dividend. The algebra version of this is $x^5 + x^4 + 3x^3 + 6x^2 + 7x + 7 \div (x - 1)$ where x is replaced by 10 as in the previous paragraph.

Going back though to the invitation to look at the number, and attempting to dig deeper into the aesthetic experience emerging from said invitation, one more example might bring us to the next level: 16 x 14. In school, we usually learn to perform the operation in columns, regardless of the numbers at play. But what happens if we look at them? We might realise that they are both two-digit numbers; they share the same ten; and their units are complementary; but also that they are both just one unit away (in excess and in defect) from 15; they can be expressed as 2^4 and 7 x 2; and what's more, that if halved they allow a quick multiplication between 8 and 7. Depending on which of these – and other possible – relations and correlations catch our attention, based on the path we decide to go on, there are different ways to get the same result. Here we spell out 5 of them with their respective sutras:

1. *By one more than the previous one*: 16x14=1x2/6x4[4]
2. *All from 9 and the last from 10* together with *Proportionately*: 16x14=16+4/6x4=20/24=224[5]
3. *Vertically and crosswise*: 16x14=1 / 10 / 24 = 224[6]
4. *Proportionately*: 16/2 x 14/2 x 2 x2= 8x7x2x2 = 224[7]
5. *By addition and subtraction*: 16 x 14 = (15 +1) (15 – 1) = $15^2 - 1^2$ = 225–1=224[8]

To a novice eye this synoptic presentation might seem a jumble of digits and illogical words. As soon as guidance is provided though in the deciphering of the underlying processes, one may be overtaken by amazement and fascination for how many and how varied are the approaches until now dwelling beneath the threshold of consciousness. It is as if we forgot for one second the goal, and we allowed ourselves the pleasure to find, trace, follow one path, while still finding at the same time new ones. This first impression may be then followed by others. Some might, for instance, claim that one method is faster or easier than another. Someone might still raise the objection that column calculations are the most economical, inasmuch as only one rule needs to be remembered and teacher verification is easy. One might, after all, variedly express the need to limit the endless number of possibilities and ask science to mediate and guarantee the value of a still-image, to take on the function of determining a state-of-affairs on a reference plane with a shared system of coordinates, «on condition of renouncing infinite movements and speeds and of carrying out a limitation of speed first of all» (Deleuze, Guattari [1991]).

But is this the only thing that *counts* in maths? And what does the Vedic method *recount* in this respect? In the above mentioned simple multiplication, what emerges is most of all the *unity* coupled with the *multiplicity* of the number: the opening of a horizon; the refraction of a ray of light into a spectrum of colours; a dynamicity of relations within an underlying whole, which is to be constantly retrieved and revived. Furthermore, by recourse to a simile, here human beings are given the opportunity to act as interpreters of digits and performers of processes. In other words, an

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[4] As we multiply two two-digit numbers, with the same ten and complementary units, the method invites to multiply the ten digit by the following one and the units by one another.

[5] In this case one works on the 10 base, adding to one number the excedence of the other to the base (16+4 or 14+6) and then multiplying the units.

[6] The aphorism invites to multiply vertically the tens by tens and units by units, then finding the products of the diagonals and adding them.

[7] In this case one reduces both numbers to smaller ones which are easier to multiply and then multiplies the result proportionally by 2.

[8] In this case, by remarking that both numbers are close to 15, one works by addition and subtraction. It should also be noted that the power of 15 is easy to calculate thanks to the *By one more than the previous one* sutra.

opportunity is here found for the aesthetic ability to interact with a script, to dig up some potentialities and meanings and not others, to choose each time what to bring on the stage. Within this continuous interplay between background and foreground, each choice – even the one deemed wrong or simply more complex and less immediate – has its *raison d'etre* in the present moment (Glover [2015]: 113). Each choice also opens up the possibility of new paths and transformations.

Going back to 16x14, the exquisitely aesthetic features of Vedic mathematics are immediately clear. All 5 sutras are correct. Then why do we choose one path over the other? As the English essayist Joseph Addison writes: «Nature delights in the most plain and simple diet» (Addison [1711]: 255, no. 195). The same re-emerging idea expressing the principle of least action which, although of ancient Greek origin, has been taken up in the 17th century by both Newton and Fermat. Based on this principle, it is assumed that behind each choice more than one equally valid and justifiable hypothesis exists – as it is precisely the case with the above presented multiplication – that is to say, several ways to re-compose multiplicity into unity and at the same time unfold the unity itself. Difference would only ensue from a higher or lower degree of simplicity and inevitability pertaining to one path rather than to the other. However, if we consider the above presented calculation, we realise that all 5 sutras – or combinations of sutras – satisfy the principle.

What moves then the scale in one direction rather than the other? One might be ignoring the other options – as happens in old-fashion teaching methods – or one might follow nature's tendency towards *least action*, as historically and subjectively determined. Preference can however also spring out of surprising and satisfying unpredictability, or on the contrary from the comforting feeling of safety found in a familiar path; and it can also be connected to personal taste and special idiosyncrasies of hard-to-account-for origins, possibly deriving from pleasure and displeasure in learning settings, educational relations, and current life experiences (Sinclair [2001]; Hankey, Shastri [2017]; Livingston [2017]).

What is clear is that Vedic mathematics legitimises and unifies all these different possibilities. Milena Ivanova wrote: «When we construct theories that conform to the principles of unity and simplicity, we are following ideals reflective of our cognitive makeup» (Ivanova [2020]: 98). Vedic methods *reflect* how our thoughts work: in fact the sutras describe neither a set of principles nor an univocal and repetitive mechanical process, but they are rather connected to «the fountainhead and illimitable store-house of all knowledge» (Bharati Krisna Tirtha [1965]: XXXIII), to the human capacity to be a channel for its discovery, enjoyment and expression, beginning with the earliest and simplest interactions with numbers.

In this respect, as it bridges the gap between different cultures, disciplines and faculties, the Vedic method is a valuable *pedagogical tool* for developing creativity, flexibility, speed and strategic skills (Glover, Williams [2016]). In the face of increasingly rampant digital dementia (Spitzer [2012]), it not only trains mental calculation and with it many cognitive abilities, but it does so by promoting personal taste and the pleasure of discovery from the earliest to the most advanced levels of study: aesthetic factors that deserve to be made known and available as much to scholars as to students and professional.

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