Geometric Narratives in Ritual Art: A Mathematical and Cultural Study of Saraswati Yantra and Aishwarya Kolam

Introduction:

Kolam[6] is a traditional art form in South India, particularly Tamil Nadu, where intricate patterns are created, often using rice flour, as part of daily rituals and for special occasions. These patterns are believed to bring prosperity and good luck. In Tamil, "kolam" (கோலம்)[5] generally means form, beauty, or design. The word can also refer to disguise or play. Kolam as a ritualistic and aesthetic art form rooted in South Indian culture, is characterized by intricate geometric or curved-line patterns traditionally drawn at the thresholds of homes. In its various other names and forms, this ritualistic pattern is spread across the whole of Indian sub-continent.

Kolams are an integral part of the yantric[2] tradition in Indian culture, particularly within Hinduism and Buddhism, where geometric and symmetrical patterns are used as tools for spiritual focus and symbolic representation.

This study centers on two distinct kolams—**Saraswati Yantra**[3,4] and **Aishwarya Kolam**[1] (Figure 1a and Figure 1b)—both of which are traditionally drawn in front of prayer altars during specific festive occasions, serving both ritualistic and meditative purposes.

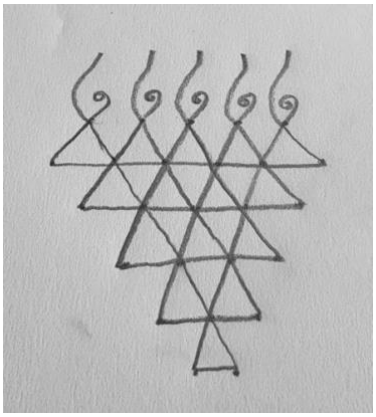


Figure 1a: Saraswati Yantra

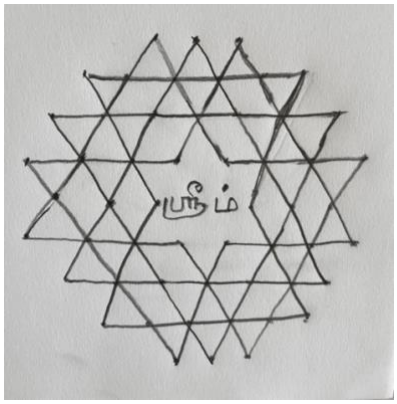


Figure 1b: Aishwarya Kolam

Saraswati Yantra:

The term "yantra"[2] literally translates to "machine" and denotes a sacred geometric diagram employed in Hindu and Buddhist practices to support meditation and concentration. Unlike kolams, patterned drawings placed on house or temple thresholds, yantras are rendered exclusively on prayer altars. As tools for inner focus, their defining features are a series of concentric triangles converging on a central point, or bindu, which anchors the practitioner's attention.

The **Saraswati Yantra** (Figure 1a) is a traditional drawing commonly created in the western and southern regions of India during auspicious occasions such as Gudi Padwa (New Year) and Navratri. Both festivals honor the goddess Saraswati[8,9], revered as the deity of knowledge, wisdom, and artistic creativity.

Unlike conventional yantras characterized by concentric triangles and a central bindu, the Saraswati Yantra presents a distinctive structure. It features a sequential arrangement of equilateral triangles that increase in number, symbolizing a progression from unity to infinity. While it diverges from the classical yantra form, this geometric composition is still referred to as a yantra, reflecting both its ritual significance and its symbolic expression of intellectual and spiritual growth.

The shapes and patterns of Saraswati Yantra:

The distinctive geometric structure of the Saraswati Yantra naturally invites exploration from both artistic and mathematical perspectives. This study investigates the construction of the yantra by analyzing its fundamental unit—**the equilateral triangle**—with the aim of developing a scalable model of the pattern from **unity to infinity**. The scaling is approached through two complementary methods:

1. **Geometric Pattern Analysis:** This approach studies the structural progression of the yantra as it scales, identifying recurring shapes and symmetries that emerge at each level of expansion. By recognizing how individual triangles are arranged and interlocked, we can derive visual and spatial rules that govern the formation of higher-order patterns.

2. **Triangular Number Series Application:** This method draws on the mathematical concept of triangular numbers, which represent the sum of the first n natural numbers. By associating each level of the yantra with a corresponding triangular number, the study seeks to derive a general formula for the n^{th} stage in the sequence. This formula can then be used to predict and construct increasingly complex versions of the yantra with mathematical precision.

Together, these approaches not only reveal the mathematical elegance embedded in the Saraswati Yantra but also open avenues for connecting traditional ritualistic art with modern mathematical frameworks. The study thus serves as a bridge between indigenous knowledge systems and formal mathematical inquiry, highlighting how sacred geometry can encode both cultural symbolism and numerical logic.

Geometric Pattern Analysis:

The pattern of Saraswati Yantra visually has 3 elements.

1. The triangles placed in an ascending order from one to many
2. The spiral pattern placed at the tip of the top most layer of upward pointing triangles
3. The open ended curved line again placed at the tip of the top most upward pointing triangles

The second and third elements of the Yantra are a recurring factor irrespective of the size of the yantra. In order to analyze the geometric pattern, this study has ignored the two elements and concentrated on the main group of triangles in the Yantra.

Figure 2a shows the most commonly drawn yantra, with the spirals and the open ended curved lines at the top, and figure 2b illustrates the yantra without the spiral and open ended curved line patterns.

Figure 2a

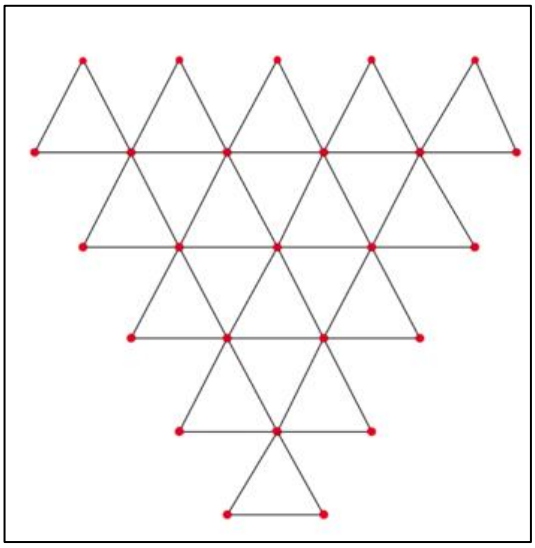
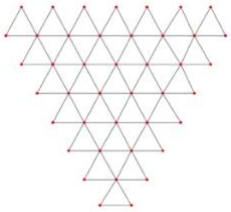
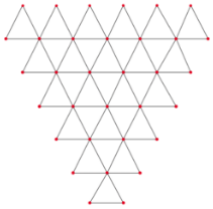
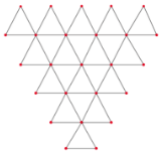


Figure 2b

Figure 2b serves as the base pattern to explore the structural logic of the Yantra by scaling it up and down. **The distance between two red dots is defined as one unit of measurement**. When the Yantra is scaled down, the fundamental building block that emerges is the equilateral triangle. Each horizontal line in the diagram is treated as a distinct layer, helping to identify the hierarchical levels within the pattern.

In Figure 2b, the topmost and longest horizontal line spans 5 units and contains 5 upward-pointing equilateral triangles. **For the purpose of this study, this is defined as the Yantra's degree as and taken as 5**. By scaling this structure both upward and downward, the following table presents Yantras of degrees 1 through 7, each illustrating how the pattern evolves across levels.

Illustration	Length of the topmost horizontal line	No. triangles in the topmost layer	Degree
	7 Units	7	7
	6 units	6	6
	5 Units	5	5
	4 Units	4	4
	3 Units	3	3
	2 Units	2	2
	1 Unit	1	1

Shape analysis of even degree Saraswati Yantras:

A closer examination of the table and the seven degrees of the Yantra reveal that all the patterns exhibit eulerian paths.

To further analyze the geometric structure of these Yantras, the study is divided into two parts. The first focuses on Yantras of even degrees—specifically degrees 2, 4, 6, and 8. In these even-degree Saraswati Yantras, two fundamental shapes recur consistently. These shapes and their spatial arrangement becomes increasingly structured as the degree of the Yantra increases.

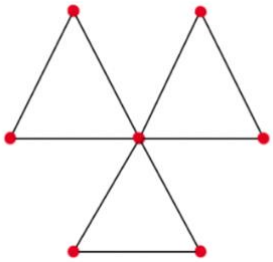


Figure 3a: shape 2

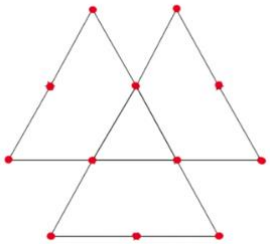


Figure 3b: shape 3

Shape 2 mirrors the structure of the degree 2 Saraswati Yantra—an Eulerian path formed by three equilateral triangles converging at a central point. As the degree of the Yantra increases, this shape retains its core configuration but expands proportionally. The spacing between the three triangles increases in accordance with the degree.

For instance, in the degree 3 Saraswati Yantra, the three triangles remain, but are now positioned 1 unit apart from each other. This spatial shift results in the emergence of a new, downward-pointing equilateral triangle formed between them, with side length equal to 1 unit (see Figure 4).

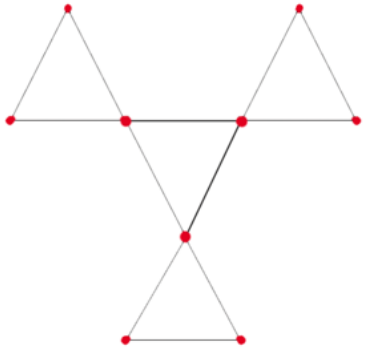
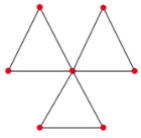


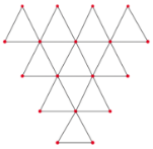
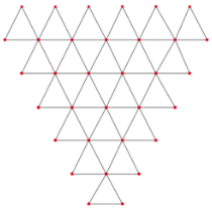
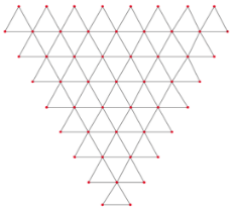
Figure 4: Extended figure 2 by 1 unit

Shape 3 represents another form of an Eulerian path, where three equilateral triangles overlap in a configuration resembling a three-way Venn diagram—using triangles instead of circles (see Shape 3b). This formation first appears in the degree 4 Saraswati Yantra. The pattern recurs across Yantras of higher degrees, with variations in scale.

The initial instance of this shape uses triangles with 2-unit side lengths, arranged in such a way that they form a smaller, embedded equilateral triangle of 1 unit at the center.

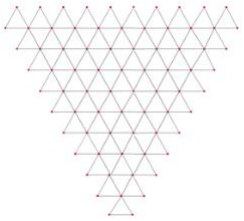
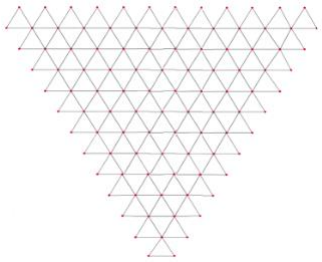
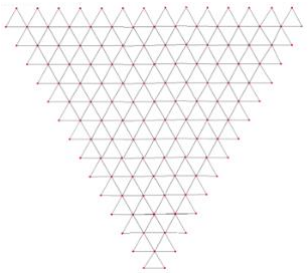
The table below breaks down the shapes in the even degree yantras of 2, 4, 6 and 8.

Degree	**Yantra drawing**	**Shape 2 - distance**	**Shape 3 – length of the side**	**Shape 3 – embedded triangle side**
2		0	0(not present)	

4		2 (single unit side triangle)	2	1
6		4 (single unit side triangle) 1 (2 unit side triangle)	3	2
8		6 (single unit side triangle) 3 (2 unit side triangle) 0 (3 unit side triangle)	4	3

An analysis of the four even-degree Saraswati Yantras reveals a consistent and predictable relationship between the degree of the Yantra, the recurrence of the two key shapes, and the distances between them. This suggests that a theory of geometric scaling based on these patterns is feasible.

While preliminary observations support this hypothesis, additional data is needed to develop a precise scaling formula using these shapes. The following table presents an extended analysis of Saraswati Yantras with degrees 10, 12, and 14 to further explore this relationship.

Degree	Yantra drawing	Shape 2 - distance	Shape 3 – length of the side	Shape 3 – embedded triangle side
10		8 (single unit side triangle) 5 (2 unit side triangle) 2 (3 unit side triangle) -1 (4 unit side triangle)	5	4
12		10 (single unit side triangle) 7 (2 unit side triangle) 4 (3 unit side triangle) 1 (4 unit side triangle) -2 (5 unit side triangle)	6	5
14		12 (single unit side triangle) 9 (2 unit side triangle) 6 (3 unit side triangle) 3 (4 unit side triangle) 0 (5 unit side triangle -3 (6 unit side triangle	7	6

Reinterpreting Shape 3: A Breakthrough in Pattern Recognition

Constructing the next three even-degree Saraswati Yantras reveals an important insight: what was previously identified as Shape 3 is, in fact, a variation of Shape 2—with a negative or reverse movement. This realization simplifies the understanding of the pattern, as the last two columns

in the earlier tables can now be seen as extensions of the same arithmetic progression established by Shape 2 in the first column.

This discovery streamlines the process of identifying and predicting the scaling pattern in even-degree Saraswati Yantras. The table below illustrates this progression, highlighting the transformation and relative positioning of the three triangles as the base increases with each even degree.

Degree	1u Triangle Distance	2u Triangle Distance	3u Triangle Distance	4u Triangle Distance	5u Triangle Distance	6u Triangle Distance	7u Triangle Distance	8u Triangle Distance
2	0							
4	2	-1						
6	4	1	-2					
8	6	3	0	-3				
10	8	5	2	-1	-4			
12	10	7	4	1	-2	-5		
14	12	9	6	3	0	-3	-6	
16	14	11	8	5	2	-1	-4	-7

Analysis of the above table will now provide with the necessary data to draw up the infinite series of the even degree Saraswati Yantra.

Definition of terms

D(n) – Saraswati Yantra with degree of nth order

u – Unit of measurement (Eg: 3u will refer to a distance/measurement of 3 units)

T_n – Equilateral Triangle with the side of n units (Eg: T_1 = Equilateral triangle with side of 1 unit)

$3T_n$ - Identified shape 2 with 3 equilateral triangles with side of n units

$3T_n$<x> - <x> represents the distance in units of the 3 triangles in the shape $3T_n$

So the Saraswati Yantra with a degree of 2 will have the following term

D(2) = $3T_1$<0> where <0> is the distance of the three triangles

D(4) = $3T_1$<2> , $3T_2$<-1>

D(6) = $3T_1$<4> , $3T_2$<1> , $3T_3$<-2> and so on.

The nth term series will thus be –

D(n) = $3T_1$<n-2> , $3T_2$<n-5> , $3T_3$<n-8>……$3T_{n/2}$<(n/2-n)-1>

The number series 2, 5, 8… in the above series can be rewritten as

2, 2+3, 2+3+3, 2+3+3+3….

Which is

2+3x0, 2+3x1, 2+3x2, 2+3x3….

So finally the even degree Saraswati Yantra series can be now be illustrated as

D(n) = $3T_1$<n-(2+3x0)> , $3T_2$<n-(2+3x1)> , $3T_3$<n-(2+3x2)>……**$3T_{n/2}$<(n/2-n)+1>**

Transition to Odd-Degree Yantras: Introduction of a New Shape

Having established that even-degree Saraswati Yantras are built around a single recurring shape, we now turn our attention to the odd-degree Yantras. Unlike their even-degree counterparts, the odd-degree Yantras introduce an additional element: a solitary equilateral triangle, appearing precisely in the middle of the yantra, along with the familiar three-triangle configuration seen in even degrees.

The shapes that consistently emerge in the odd-degree Saraswati Yantras are:

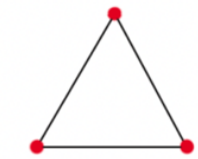


Figure 5a: Shape 1(Triangle)

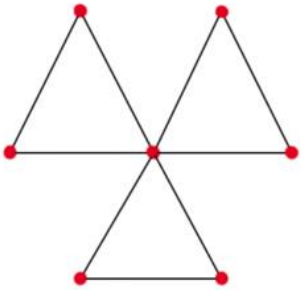
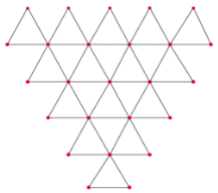
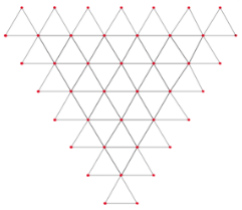
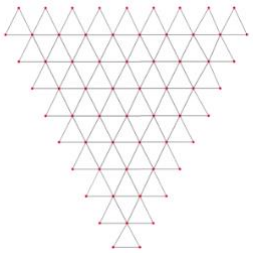
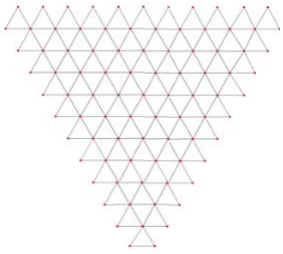


Figure 5b: Shape 2(used in even degree yantras)

The following table has the shapes study of the odd degree yantras from 1 to 11.

Degree	Yantra drawing	Shape 1 (Length of base)	Shape 2 (Distance)
1		1 Unit	NA
3		2 units	1u (1)

Degree	Yantra drawing	Shape 1 (Length of base)	Shape 2 (Distance)
5		3units	1u(3) 2u(0)
7		4units	1u(5) 2u(2) 3u(-1)
9		5units	1u(7) 2u(4) 3u(1) 4u(-2)
11		6units	1u(9) 2u(6) 3u(3) 4u(0) 5u(-3)

The following table illustrates the progression and spatial movement of the three-triangle configuration alongside the singular equilateral triangle as the base increases in the odd-degree Saraswati Yantras.

Degree	Shape 1 Triangle base	1U Triangle Distance	2U Triangle Distance	3U Triangle Distance	4U Triangle Distance	5U Triangle Distance
1	1					
3	2	1				
5	3	3	0			
7	4	5	2	-1		
9	5	7	4	1	-2	
11	6	9	6	3	0	-3

Using the same definition of terms as the even degree Saraswati Yantra series,

The side of the singular equilateral triangle can be arrived with the formula

$D(n) = T_{(n+1)/2}$

For example, the side of the triangle for the yantra with degree 9 will be

= (9+1) /2

= 10/2

= 5

the nth term of the series will now end at (n – 1)/2

Hence, series of the odd degree Saraswati Yantra will thus be –

$D(n) = 3T_1\langle n-(2+3x0)\rangle, 3T_2\langle n-(2+3x1)\rangle, 3T_3\langle n-(2+3x2)\rangle \ldots \mathbf{3T_{(n-1)/2}\langle\{[(n-1)/2]-n)\}+3\rangle} + \mathbf{T_{(n+1)/2}}$

Triangular Number Series in the Saraswati Yantra:

In the second part of this enquiry, the fundamental structure of the Saraswati Yantra—specifically the arrangement of 1-unit upward-pointing triangles at each degree—intuitively reveals the presence of the triangular number series.

Counting these 1-unit triangles at each degree, the following table illustrates the emerging numerical pattern.

Degree	Number of 1unit upward Triangles
1	1
2	3
3	6
4	10
5	15
6	21
7	28
8	36
9	45

Triangular numbers[11] are a sequence of numbers that can be visually represented as dots arranged in the shape of an equilateral triangle. In the Saraswati Yantra, this dot pattern is replaced by 1-unit equilateral triangles. As a result, the total number of these 1-unit triangles at each degree corresponds to a triangular number. Specifically, the *n*th degree of the Yantra contains exactly the *n*th triangular number of 1-unit triangles.

The formula to find out the triangular numbers is $t = n(n+1)/2$

In the table above, Yantra D(9) will have the 9^{th} triangular number that can be arrived using the above formula. Replacing n by 9,

$= 9(9+1)/2$

$=90/2$

$=45$

Saraswati Yantra – A symbol of infinite knowledge:

The Saraswati Yantra serves as a sacred tool of veneration. In southwestern regions of India, particularly in households across Maharashtra and northern Karnataka, it is traditionally drawn during Gudipadwa[12] (the New Year) and the festival of Navaratri[13]. Beyond these occasions, the yantra is also commonly placed in workspaces and children's study areas to invoke the blessings of Goddess Saraswati, the deity of knowledge and wisdom.

In both ritual and everyday contexts, the yantra is intended to attract abundant knowledge. Exploring the mathematical patterns within the yantra reveals its deeper symbolic significance—especially its scalability and the emergence of an infinite series from a single unit. This progression from unity to infinity beautifully mirrors the Indian philosophical view expressed in the Vedas and Upanishads: that the ultimate reality (Brahman) is both one and infinite. The yantra thus becomes not only a devotional drawing but also a visual embodiment of Advaita, or Non-Dualism, where unity and boundlessness coexist.

The following sloka appears as the opening verse of the Isavasya Upanishad[7], often recited as an invocation:

ॐ पूर्णमदः पूर्णमिदं पूर्णात् पूर्णमुदच्यते।

पूर्णस्य पूर्णमादाय पूर्णमेवावशिष्यते॥

Om pūrṇam adaḥ pūrṇam idaṁ pūrṇāt pūrṇam udacyate
Pūrṇasya pūrṇam ādāya pūrṇam evāvaśiṣyate

Meaning:

That (Brahman) is full; this (creation) is full. From the fullness (of Brahman), this fullness has come. Even when fullness is taken from fullness, fullness still remains.

This verse encapsulates the concept of infinity—an idea that is both metaphysical and, in many ways, mathematical. The fullness (pūrṇam) referred to here translates seamlessly into the modern understanding of infinity, suggesting that the divine source remains infinite even as it gives rise to an infinite creation.

In this light, the Saraswati Yantra can be seen as a visual embodiment of this profound idea. Its structure, rooted in symmetry and recursion, symbolizes infinite growth and endless expansion. As a representation of the goddess of knowledge, the yantra reflects the infinite nature of Brahman—the ultimate reality as described in the Vedas[14]. Thus, the Saraswati Yantra is not only an object of devotion but also a powerful intersection of mathematics and metaphysics, illustrating the infinite pursuit of wisdom.

Aishwarya Kolam:

The Aishwarya Kolam[1] is a traditional ritual design drawn on prayer altars, most commonly on Fridays—a day associated with abundance and auspiciousness in many Indian households—and during special festive occasions. At the heart of the design lies a dot, sometimes a writing like "Om" or "Shreem" also appear here. Symmetrical lines extend outward, forming concentric triangles that radiate harmony and balance. The repetitive, geometric nature of the kolam is not only visually striking but also deeply meditative, aligning with broader yantric principles found in Hindu and Buddhist traditions.

More than just decorative art, the Aishwarya Kolam carries rich symbolic meaning. The word Aishwaryam itself translates to prosperity or abundance, and the kolam is believed to attract wealth, well-being, and positive energy into the home. Through its geometric precision and cultural significance, the Aishwarya Kolam exemplifies how ritual art in Indian traditions seamlessly integrates the spiritual, mathematical, and aesthetic, serving as a bridge between daily life and metaphysical aspiration.

Earlier work and study on Aishwarya Kolam:

Author Srinivasan R in his study titled "Scalable Hridaya Kamalam and Aishwarya Kolam" [1] presents a detailed analysis on the patterns appearing in the Aishwarya Kolam and has generated methods of scaling the kolam identifying the shapes and the distances within the shapes. The Hridaya Kamalam is another Kolam that is drawn in the alters on Fridays just like the Aishwarya Kolam.

In Scaling the Aishwarya Kolam, the paper looks into the pattern most commonly drawn (illustrated in figure 6 below)

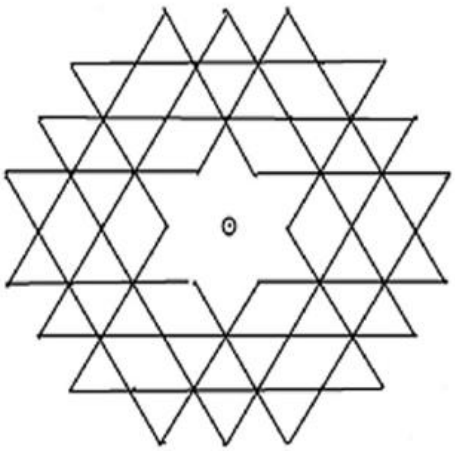


Figure 6 – Aishwarya Kolam

The paper further examines the geometric forms found in the Kolam, identifying recurring patterns such as the "Damru"[15] and the "Triangle" (Figure 7). It analyzes these shapes and the spatial relationships between their connecting lines to derive a formula for scaling the Kolam. This approach closely parallels the methodology used in this paper to understand the structure and scalability of the Saraswati Yantra. The study concludes by suggesting future avenues of exploration, including the possibility of examining Kolam patterns in three-dimensional space and other higher dimensions.

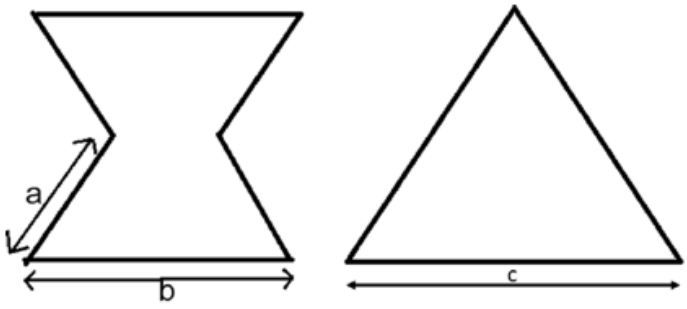


Figure 7 – Damru and Triangle

Visual Pattern recognition – Saraswati Yantra and Aishwarya Kolam

At first glance, the Aishwarya Kolam and the Saraswati Yantra appear to have little in common visually. The Saraswati Yantra is predominantly triangular in structure, while the Aishwarya Kolam adopts a more hexagonal configuration. Their outward forms suggest distinct geometrical frameworks. However, a closer examination reveals a surprising and elegant connection: the Saraswati Yantra is embedded within the Aishwarya Kolam—six times over.

To uncover this hidden relationship, one must begin by connecting the inner nodes of the central star pattern in the Aishwarya Kolam to form a regular hexagon (See figure 8a and figure 8b). This geometric construction provides the foundation for further analysis.

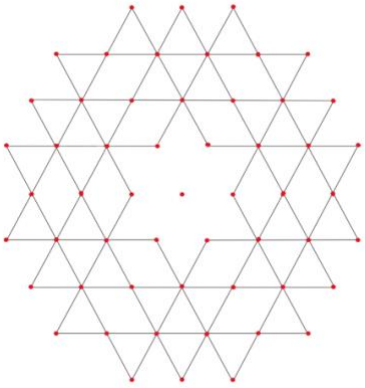


Figure 8a: Aishwarya Kolam

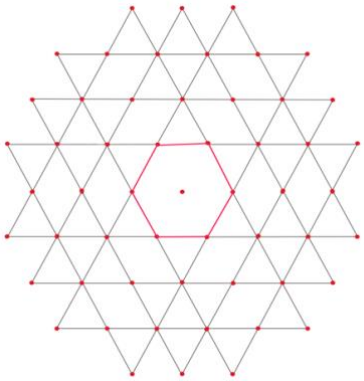


Figure 8b: Aishwarya Kolam with inner nodes joined

Once the hexagonal boundary is established, it becomes apparent that the Kolam contains six identical Saraswati Yantras arranged symmetrically around a central point (see Figure 9). Figure 9 depicts the most commonly drawn form of the Aishwarya Kolam, with the modification—joining the inner nodes. This adjustment reveals six instances of the degree-3 Saraswati Yantra (one of them highlighted in green), radiating outward in alignment with the six sides of the regular hexagon. As the Aishwarya Kolam is scaled up or down, it continues to display this radial repetition, consistently containing six Saraswati Yantras of the same degree as the Kolam itself. The Kolam now exhibits six fold rotational symmetry, with six identical instances of the Saraswati Yantra arranged equidistantly around the central axis

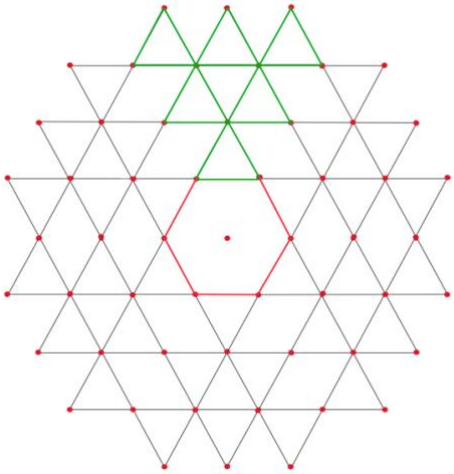


Figure 9 : Identifying Saraswati Yantras in the Aishwarya Kolam

Consequently, the Aishwarya Kolam can be interpreted as a radial tessellation of Saraswati Yantras. Scaling the Kolam up or down by any degree n results in a structure containing 6n unit triangles of the Saraswati Yantra, preserving both the hexagonal symmetry and the underlying recursive geometry of the Saraswati Yantra.

This discovery not only highlights a deep structural unity between the two designs but also opens up further possibilities for exploring the interplay between triangular and hexagonal number patterns through traditional kolam art.

Shared Symbolism and Structural Distinctions Between Saraswati Yantra and Aishwarya Kolam

The Saraswati Yantra is drawn to invoke the blessings of the goddess of knowledge and wisdom, while the Aishwarya Kolam venerates the goddess of wealth and prosperity. Despite their distinct intentions, both designs share a common underlying theme—the pursuit of abundance, whether in learning or material well-being. Each pattern is traditionally drawn on prayer altars during specific festive occasions, serving not only as sacred symbols but also as tools for meditation and focused intention.

While united in purpose, the two patterns differ significantly in form, structure, and cultural context. The following table outlines the key distinctions between the Saraswati Yantra and the Aishwarya Kolam.

Aspect	Saraswati Yantra	Aishwarya Kolam
Deity Invoked	Goddess Saraswati – deity of knowledge, wisdom, and creativity	Goddess Lakshmi – deity of wealth, prosperity, and abundance
Occasions Drawn	Gudi Padwa, Navratri, and other festivals associated with learning and the arts	Fridays and festivals dedicated to prosperity and household well-being
Placement	Drawn exclusively on prayer altars	Also drawn on prayer altars, particularly in domestic rituals
Geometric Structure	Composed of increasing equilateral triangles, forming a triangular pattern	Features concentric, symmetrical designs arranged in a radial hexagonal layout
Symbolic Intention	Represents the expansion of knowledge from unity to infinity	Embodies the flow and gathering of prosperity through balanced symmetry
Traditional Label	Called a *Yantra*, though it visually lacks the central bindu[16] and floral motifs typical of yantras	Called a *Kolam*, but includes a central bindu[16] and symmetrical structure aligned with yantric principles

Conclusion and Directions for Future Research:

This study undertook an in-depth exploration of the Saraswati Yantra, revealing its underlying structure embedded within the Aishwarya Kolam. The investigation opened up a wealth of possibilities for further research. The current analysis focused primarily on the one-unit upward-pointing triangles of the yantra, linking them to triangular numbers. However, a more comprehensive study including the larger and downward-pointing triangles could yield further insights into geometric and numerical relationships, particularly in relation to triangular number sequences.

Secondly, the mathematical parallels between the Aishwarya Kolam and the Saraswati Yantra merit deeper examination. This study established a direct correlation between the Saraswati Yantra and triangular numbers, and that the Saraswati Yantra when arranged within a hexagonal structure formed the Aishwarya Kolam. It would be worthwhile to analyze whether the Aishwarya Kolam itself gives rise to a new sequence—perhaps a modified triangular series or even a hexagonal number series.

Finally, the Saraswati Yantra has also been investigated by Dr. Sujata, a former space scientist from ISRO (Indian Space Research Organization), who presented an experimental 3D model on her YouTube channel[4]. Given the findings in this paper that identify multiple instances of the Saraswati Yantra within the Aishwarya Kolam, a natural progression would be to explore the generation of a three-dimensional Aishwarya Kolam. Such an investigation could open new dimensions - both literally and figuratively - in understanding this rich confluence of sacred geometry and mathematical structure.

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