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Beyond Geometry: Examining Multi-dimensional Pedagogical Strategies in Sulba Sutras

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Abstract:
This study explores the pedagogical insights inherent in the Sulba Sutras, ancient Indian mathematical texts detailing the construction of Vedic ritualistic altars. Findings reveal that the Sutras employ the equation method written in Sanskrit, emphasizing the importance of ratios, proportions, and measurements following a constructivist learning approach. Real-world objects and tools were utilized, fostering hands-on engagement and problem-solving skills. The study concludes that the Sulba Sutras offer a holistic and joyful learning experience, showcasing the immediate relevance of these pedagogical strategies of mathematics in deep geometrical understanding among students.

Keywords- Sulba Sutra, Vedic rituals, mathematics, pedagogies, constructivist learning.

Introduction:

The Sulba Sutras are a collection of ancient Indian texts that form a part of the larger corpus of the *Kalpa Sutras* (Filliozat, 2004), which are auxiliary Vedic texts dealing with rituals and ceremonies. The term 'Sulba Sutra' translates to 'rules of the cord,' whereas 'sulba' refers to the cord used by Brahmins as a measure in sacrificial rituals. The primary focus of the Sulba Sutras is on the construction of fire altars required for Vedic rituals and ceremonies (Seidenberg, 1961) like the Agnihotra, Agnicayana, Ashwamedha, Soma Sacrifice etc. They provide detailed instructions on the geometric and mathematical aspects of constructing various types of altars with precise measurements, proportions, and shapes. The Sulba Sutras are known for their mathematical sophistication in geometry (Dutta, 2016) and contain rules for constructing altars of different shapes, such as squares, rectangles, and circles while maintaining specific proportions. The Sutras involve concepts of ratios, proportions, and right-angled triples (sets of three integers a, b, and c such that $a^2 + b^2 = c^2$).
Since the Sulba Sutras are renowned for their mathematical foundations, however, their discovery also becomes important in the context of the historical roots of mathematical learning and its interconnection with ritual practices in ancient India. Therefore, an attempt has been made to trace the popular methods and techniques of learning mathematics in ancient India through these texts. The objective of this paper was to identify the popular methods and techniques of learning mathematics influenced by the Sulba Sutra in ancient India.

Methodology:

To accomplish the objective of the study, which is to identify the popular methods and techniques of learning mathematics influenced by the 'Sulba Sutra' in ancient India, the researchers employed the content analysis method, a research technique that involves systematically examining the textual content to identify specific themes, concepts, and patterns (White & Marsh, 2006.). Pertinent sections of the *Baudhayana Sulba Sutra* were selected for analysis, utilizing established translations and developing a coding framework to categorize mathematical teachings, instructional methods, and pedagogical principles. The content analysis systematically applied this framework, extracting insights into mathematical education, learning methodologies, and instructional techniques. The study concluded with comprehensive documentation and reporting of findings, contributing to a nuanced understanding of the methods and techniques employed in learning mathematics influenced by the *Baudhayana Sulba Sutra* in ancient India.

Results and Discussions:

To examine the methods and techniques of learning mathematics in ancient India, a close analysis of the Sulba Sutra has yielded enlightening insights. The results show that a multidimensional approach to learning mathematics was implicit in the instructions of the Sulba Sutra, which are systematically described below under different headings:

- **Sutra or Equation Method:**

Each of the Sulba-sutras indeed exists as a complete mathematical equation in itself, providing the necessary information for a specific geometric operation. They express precise geometric procedures concisely and systematically. The modern mathematical notations we use today were embedded in abbreviated form using the Sanskrit language. For example, in B.S. 1.59 the numerical ratio is described in Sanskrit language.

मण्डलं चतुरस्त्रं चिकीर्षन् विष्कम्भमष्टौ भागान्कृत्वा भागमेकोनत्रिंशधा विभज्याष्टाविंशतिभागानुद्धरेद्

भागस्य च षष्ठमष्टमभागोनम् ।। 1.59 ।।

If you wish to transform a circle into a square, having divided the diameter into eight parts and one of these eight parts into twenty –nine parts, remove twenty-eight parts; remove the sixth part of the remaining one part less the eighth part of the sixth part. (B.S.1.59)

These instructions emphasize a nuanced use of ratios and proportions, showcasing the mathematical sophistication inherent in ancient Indian mathematical texts. It contains a poetic style, which is a peculiar style of Sanskrit writing, which was used in Sulba texts and, hence, used for its learning also. A similar finding is reported by Joseph (2001). This lyrical poetic format, with its mnemonic devices and oral tradition compatibility, made it easier for practitioners to preserve, understand, and apply this sacred knowledge within the Vedic tradition.

- **Procedural Instructions:**

अथापरं प्रमाणादध्यर्धा रज्जुमुभयतः पाशां कृत्वा

परस्मिस्तृतीये षड्भागोने लक्षणं करोति ।। 1.42 ।

There is another method for drawing a square \oblong. Having made slings at both the ends of the cord the length of which is equal to one and a half of the length of the required square\oblong, make a mark on its western third less the sixth part of the third. (B.S.1.42)

तत्रयञ्छनम् ।। 1.43 ।।

This is the Nyanchana mark. (B.S.1.43)

इष्टेडसार्थम् । पृष्ठ्यान्तयोः पार्शौ प्रतिमुच्य न्यञ्छनेन

दक्षिणापायमयेष्टेन श्रोण्यसात्रिर्हरेत् ।। 1.44 ।।

Make another mark at the desired point for fixing the corners of the square /Oblong. Having fixed the slings at both ends of the east-west line stretch the cord with the nyanchana mark towards the south and ascertain *the sronis (south–west and north–west corners)and the amass (south–east and north-east corners) of the square /oblong.(B.S.1.44)*

अथाश्वमेधे विंशत्याश्च रथाक्षाणमिकविशंत्याश्च पदानामष्टाङ्.गुल्स्य च चतुर्विशं भागमाददीत। स प्रक्रमः स्यात् तेन वेदिं विमिमीते ।। 1.108 ।।

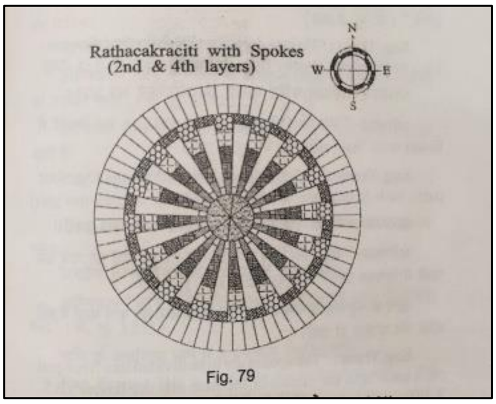
Similarly, in the context of the asvamedha sacrifice, find the value of the 24th part of 20 rathakas,21 padas and 8 angulas; this is the new measure of the prakrama; construct the vedi with this prakrama. (B.S.1.108)

In the context of the Asvamedha sacrifice, the Sutra (B.S. 1.108) step-wise- step instructs to find the dimensions of the altar by calculating the 24th part of 20 rathakas (X), 21 padas (Y) and 8 angulas (Z). These measurements are divided by 24 to determine the new measure of the prakrama, which is the perimeter or boundary of the altar. The resulting values for X, Y, and Z are then used to construct the Vedi, ensuring that it adheres to the specified proportions required for the Asvamedha sacrifice, a significant Vedic ritual involving the consecration of a horse. Thus, the Sutras provide step-by-step procedural instructions for constructing geometric shapes for fire altars. Dutta & Sriram also called this text as Sulba Procedure. These instructions included details about measurements, calculations, and the order in which different components should be constructed.

- **Learning through Art:**

रथचक्रचितं चिन्वीतेति विज्ञायते ।। 3.179 ।।

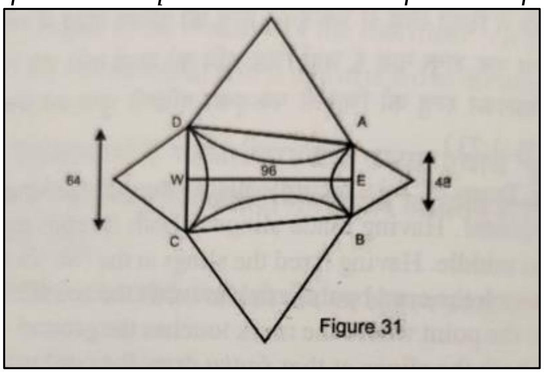
He is to construct the rathacakracit (the Agni in the form of a chariot –-wheel, says the Sruti (B.S.3.179)



Picture 1, Source: Baudhayna Sulbasutra

अपरेणाहवनीयं यजमानमात्री भवतीतिदार्शपौ र्णसमासिकाया वेदे र्विज्ञायते ।। 1.71 ।।

The measure of the darsapaurnamasiki altar yoshita (woman) is known from the holy texts. It is to the west of the Ahavaniya fire and is equal to the measure of the sacrificer. (B.S.1.71)



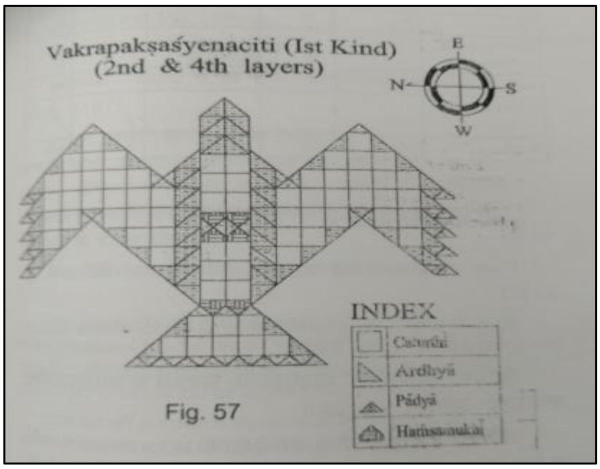
Picture 2 Source: Baudhyana Sulbasutra

The given sutras and related pictures (Pictures 1-2) of the altars are seen as supporting learning through art in the sense that they involve practical applications of geometry in the creation of complex and aesthetically pleasing geometric patterns in altars. The B.S. 3.179 talks about constructing the rathacakracit, representing an altar in the form of a chariot wheel. By creating this altar, individuals were not only engaged in applying mathematical principles of symmetry and proportions but also in artistic expression. The B.S. 1.71 instructs on the construction of the darsapaurnamasiki altar, specifically associated with the shape of women. This altar's dimensions were calculated based on texts, emphasizing the importance of fundamental mathematical concepts of measurement and proportion. The act of constructing this altar involves the application of these mathematical concepts while also being an artistic endeavour. Thus, the creation of the geometric patterns for the altars was an artistic endeavor that involved both mathematical precision and aesthetic considerations. The process of creating these patterns required careful attention to symmetry, proportion, and visual harmony, all of which are important aspects of art (Jarvis & Naested 2012).

- **Learning through Natural Structure:**

अथ वै भवति श्येनचियतं चिन्वीत स्वर्गकाम इति ।। 3.1 ।।

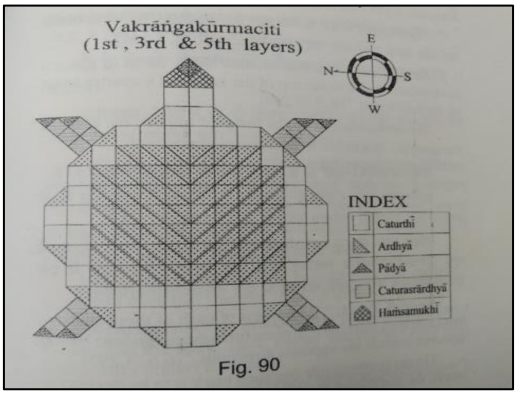
He who yearns for heaven should construct the Syenacit (an altar in the shape of a falcon), says the Sruti. (B.S.3.1)



Picture 3, Source: Baudhyana Sulbasutra

द्वयाः खलु कूर्मा भवन्ति वक्राङगश्च परिमण्लाश्च ।।3.271 ।।

There are two kinds of tortoises, viz the vakrangas (with angular limbs) and the parimandalangas (with circular limbs). (B.S.3.271)



Picture 4, Source: Baudhyana Sulbasutra

पशुर्वा एष यदग्निर्योनिः खलु वा एषा पशोर्विक्रीयते यत्प्राचीनमैष्टकाद्यजुः क्रियते इति ।। 2.41 ।।

Our ancient tradition says that this Agni is an animal; the yoni of this animal is shaped in different ways; before the placement of the bricks in the Agni is performed a ceremony in which the mantras of Yajurveda are recited. (B.S.2.41)

The sutras offer steering on building altars with precise shapes. B.S. 3.1 prescribes the creation of a *Syenacit* (Picture 3) altar shaped like a falcon, whilst B.S. 3.271 distinguishes between two types of tortoise-shaped altars (Picture 4), one with angular limbs and another with circular limbs. B.S. 2.41 refers to Agni, the sacred fire, with an animal, with the yoni taking different shapes.

हंसमुखीं पुरस्तात् ।। 3.88 ।।

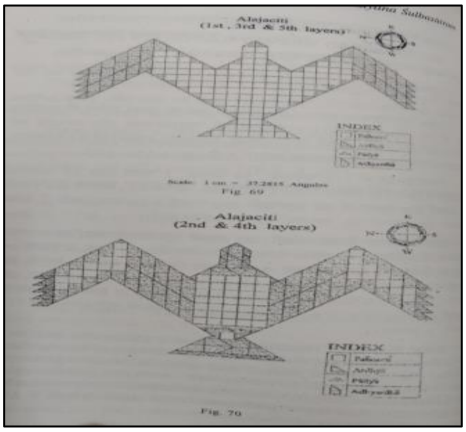
He is to place a hamsamukhi (pentagon shaped) to the east of the caturthi. (B.S.3.88)

पशुधर्मो हवा अग्निर्यथा ह वै पशोर्दक्षिणवामस्थां यद्दक्षिणं पार्श्वं तदुत्तरेषामुन्तरं यदुन्तरेषां दक्षिणं तद्दक्षिणेमामुत्तर यदवाक् चोर्ध्वं च तत्समानमेवमिष्टकानां रूपाण्युपदध्यात् ।। 2.29 ।।

The Agni, indeed, resembles an animal; because the southern end of the right side ribs of an animal is like the northern side of the north half of the Agni; the southern end of the left side ribs is like the northern end of the south half of the Agni; the western and the eastern parts are alikes; therefore, the bricks should be placed accordingly. (B.S.2.29)

अलजचित् एतेनात्मा शिरः पुच्छं च व्याख्यातं पादावपोद्धृत्य ।।3.153 ।।

Thereby the body, the head and the tail of the Alajacit are considered to be explained except the feet (as it has no feet). (B.S.3.153)



Picture 5, Source Baudhyana Sulbasutra

B.S. 3.88 instructs the placement of a pentagon-shaped *Hamsamukhi* structure to the east of the *Caturthi.* Also, B.S. 2.29 draws a parallel between the Agni altar's structure and the anatomy of an animal, especially its ribs. B.S. 3.153 introduces an *Alajaciti* (Picture 5) altar, explaining its frame, head, and tail, highlighting its unique feature of missing feet. Thus, it is evident that the Sulba Sutras used natural structures and patterns as a basis for altar construction. These texts often describe the shapes and proportions of altars by referencing familiar natural objects like falcons, tortoises etc. This approach served as an early pedagogical technique, demonstrating how geometry could be learned and applied through observation and analogies with the natural world.

➢ **Use of Everyday Tools in Learning:**

चतुरस्रं चिकीर्षन्यावच्चिकीर्षेत्तावतीं रज्जुमुभयतः पाशां कृत्वा मध्ये लक्षणं करोति। लेखामालिरव्य ।। 1. 22 ।।

If you wish to draw a square, take a cord of the required length, make slings at both its ends and a mark at its middle. Then having stretched the cord east-west draw a line (praci). (B.S.1.22)

तस्या मध्ये शङ्कुं निहन्यात्। तस्मिन्याशौ प्रतिमुच्य लक्षणेन मण्डलं परिलिखेत्। विष्कम्भान्तयोः शङ्कू निहन्यात्।। 1.23।।

Fix a sanku at the mid-point of that line (east –west line); then having fixed the slings on the sanku, draw a circle with the mark; fix sankus at both ends of the diameter(i.e.praci). (B.S.1.23)

पूर्वस्मिन्पाशं प्रतिमुच्य पाशेन मण्डलं परिलिखेत्।। 1.24।।

Having fixed one sling at the eastern Sanku (of the praci) draw a circle with the other sling. (B.S.1.24)

एवमपरस्मिंस्ते यत्र समेयातां तेन द्वितीयं विष्कम्भमायच्छेत्।। 1.25।।

Similarly, draw a circle around the western Sanku; draw a second diameter by joining the points where these two circles intersect. (B.S.1.25)

विष्कम्भान्तयोः शङ्कू निहन्यात्।। 1.26।।

Fix sankus at both ends of the (north-south diameter. (B.S.1.26)

पूर्वस्मिन्पाशौ प्रतिमुच्य लक्षणेन मण्डलं परिलिखेत्।।1.27।।

Having fixed both the slings on the eastern sanku, draw a circle with the mark. (B.S.1.27)

एवं दक्षिणत एवं पश्चादेवमुत्तरतः तेषां येऽन्त्याः संसर्गा—स्तच्चतुरस्त्रं संपद्यते ।। 1.28।। *Similarly, three circles are to be drawn around the southern, the western and the northern sankus; the points of intersection (in the intermediate directions) of these four circles will be the four corners of the required square. (B.S.1.28)*

In the series of sutras from B.S. 1.22 to B.S. 1.28, a method for constructing a square is given, using different objects. B.S. 1.22 instructs using *cords* for measurement and alignment, while B.S. 1.23 introduces the use of a *Sanku* at the side of slings. Subsequent sutras, including B.S. 1.24 and B.S. 1.27, emphasize the proper placement of slings and the eastern *Sanku*. B.S. 1.25 focuses on drawing circles across the western *Sanku*, and B.S. 1.26 directs the fixation of *Sankus* on the north-south diameter's ends. The final step, B.S. 1.28, underscores drawing three circles across the southern, western, and northern *Sankus*, which intersect to define the rectangular corners. Thus, the construction of a square involves the use of *cords, slings and sankus* as essential tools. Utilizing these kinds of tools in learning geometry has relevance and potential academic value in modern mathematics education. It gives a visual representation of geometric principles and helps students visualize angles, proportions, and relationships between diverse elements of a shape. Gaining knowledge of geometry via these kinds of equipment also bridges the gap between mathematics and other subjects like art, engineering, and architecture supported by Kappraff (2001). Students can explore the interdisciplinary components of geometry.

- **Learning Through Culture and Religious Practices:**

कूर्मचितं चिन्नीत यः कामयेत ब्रह्मलोकमभिजयेयमिति विज्ञायते ।। 3.270।।

He who wishes 'may I conquer the Brahmaloka' is to construct the Kurmacit, says the Sruti. (B.S.3.270)

अथाश्वमेधे विंशत्याश्च रथाक्षाणमिकविंशंत्याश्च पदानामष्टाङ्गुल्स्य च चतुर्विशं भागमाददीत। स प्रक्रमः स्यात् तेन वेदिं विमिमीते ।। 1.108।।

Similarly, in the context of the asvamedha sacrifice, find the value of the 24th part of 20 rathakas,21 padas and 8 angulas; this is the new measure of the prakrama; construct the vedi with this prakrama. (B.S.1.108)

छन्दश्चितं त्रिषाहस्त्रस्य परस्ताच्चिन्वीत।। 2.81।।

After the trisahasra altar (the Agni consisting of three thousand bricks , the yajamana should construct the chandascit (an Agni consisting as it were of mantras). (B.S.2.81)

लोकबाधीनि द्रव्याण्यवटेषूपदध्यात्।। 2.42।।

Those material things such as the heads of five sacrificial animals etc. which can displace the bricks are to be placed into the avatas (holes). (B.S.2.42)

These mentioned sutras provide instructions for choosing the shape of the fire altars as per the purpose of the religious or sacrificial ritual. For example: if someone desires to achieve Brahmaloka, he would construct

Kurmacit (B.S. 3.270). The specific measurements and instructions for constructing the altar for the Asvamedha sacrifice, a holy ritual that kings performed to attain power and perfection (Gupta, 2013), were given. The sutras contain units of measurement like rathakas, padas, and angulas to determine the dimensions of the prakrama (boundary) of the altar, which is a crucial part of the ritual. Hence, it is firmly stated that the Sulba Sutras vividly demonstrate how mathematical knowledge was deeply intertwined with culture and religious practices in ancient India. These sutras not only reveal the practical application of geometry and measurement in constructing altars for sacred rituals but also exemplify how mathematics was an integral part of the cultural and spiritual fabric of the society. By seamlessly blending mathematical principles with cultural and religious traditions, the Sulba Sutras serve as a testament to the profound connection between mathematics and the rich human heritage advocated by Divakaran (2018).

- **Constructivist Learning:**

अथापरम् ।। 1.29 ।।

Another method of constructing a square is being explained. (B.S.1.29)

प्रमाणाद् द्विगुणां रज्जुमुभयतः पाशां कृत्वा मध्ये लक्षणं करोति ।। 1.30 ।।

Take a cord to double the measure of the side of the required square; make slings at both ends and mark its middle. (B.S.1.30)

स प्राच्यर्थः ।। 1.31 ।।

The piece of cord (thus obtained by the middle mark) is to be used for the measure of the praci. (B.S.1.31)

अपरस्मिन्नर्धे चतुर्भागोने लक्षणं करोति ।। 1.32 ।।

तन्नयञ्छनम् ।। 1.33 ।।

Make a mark on the western half of the cord at a distance of one-fourth of the half portion from the mid-point. This mark is called nyanchana. (B.S.1.32-33)

अर्धेडसार्थम् ।। 1.34 ।।

Make another mark at the half of the western half portion of the cord to fix the corners of the square. (B.S.1.34)

पृष्ठ्यान्तयोः पाशौ प्रतिमुच्य न्यञ्छनेन दक्षिणापायम्यार्धेन श्रोण्यसात्रिर्हरेत् ।। 1.35 ।।

Having fixed the two slings at the two ends of the east-west line, stretch the cord with the nyanchana mark towards the south; fix the four corners of the square by the mark at the half of the western portion of the cord. (B.S.1.35)

मन्त्रव्यतिरेकेडक्ताः शर्कराः संधिषूपदध्यात् ।।2.47 ।।

From B.S. 1.29 to B.S. 1.35 involve practical instructions for constructing square shaped altar, using measurements and geometric principles. This required active engagement and participation on the part of the creator. This hands-on engagement with geometric principles in a creative and meaningful context aligns with the principles of constructivist learning. The construction of complex geometric shapes for the altars involves problem-solving skills. Constructing fire altars by following the instructions in the Sulba Sutras likely required learners to reflect on their work and adjust their approach if needed. B.S.2.47 exhibits a decision-making component in altar construction, showcasing the practitioners' autonomy and adaptability. It means that within this ritual context, individuals have the autonomy to cope with situations wherein there are extra sacred mantras than bricks, using pebbles anointed with clarified butter, similar reported by Glucklich (2008). It shows that practitioners needed to apply their understanding and judgment to execute the instructions accurately. This encourages a degree of autonomy and personal decision-making.

- **Multidisciplinary Learning:**

मण्डलं चतुरस्त्रं चिकीर्षन् विष्कम्भमष्टौ भागान्कृत्वा भागमेकोनत्रिंशधा

विभज्याष्टाविंशतिभागानुद्धरेद् भागस्य च षष्ठमष्टमभागोनम् ।। 1.59 ।।

If you wish to transform a circle into a square, having divided the diameter into eight parts and one of these eight parts into twenty –nine parts, remove twenty-eight parts ; remove the sixth part of the remaining one part less the eighth part of the sixth part. (B.S.1.59)

चतुरस्त्राच्यतुस्त्रं निर्जिहीर्षन्यावत्रिर्जिहीर्षेत्तस्य करण्या वर्षीयसो वृध्रमुल्लिखेत्। वृध्रस्य
पार्श्वमानीमक्ष्णयेतरत्पा र्श्वमुप संहरेत्। सा यत्र निपतेन्तदयच्छिंधात्। छित्रया निरस्तम्।। 1.51।।

If you are desirous of deducting one square from another one , cut off an oblong from the larger square with the side of the smaller square; draw the cord representing the longer side of this oblong across the oblong so that it touches the other side; remove the excess portion; thus , the remaining portion of the side will deduct the desired smaller square. (B.S.1.51)

The above sutras (B.S. 1.51, B.S. 1.59) demonstrate that the primary content of the Sulba Sutras is mathematical specifically geometrical instructions. Understanding these texts gives a solid foundation in geometry. The Sulba Sutras were written in Sanskrit. Proficiency in Sanskrit was essential for reading, interpreting, and understanding the sutras.

अश्वमेधमप्राप्तं चेदाहरेदत ऊधर्व विधामभ्यस्येत्रेतरदाद्रियेत्।। 2.9।।

In case, if the Asvamedha is to be performed without having reached the vimsatividhagni (twenty–fold altar), then for the next Agni, one square purusa is to be added in the Asvamedhagni ;no other rule is to be applied. (B.S.2.9)

अतीतं चेदाहरेदाह्त्य कृतान्तादेव प्रत्याददीत।। 2.10।।

If the Asvamedha sacrifice is to be performed after having been passed the required Agni i.e. Ekavimstividhagni, then after the sacrifice, the yajamana to attain the next Agni, is required to proceed from the Agni constructed before the Asvamedha altar. (B.S.2.10)

The B.S.2.9, B.S.2.10 guided the construction of altars used in *Ashwamedha* yajna. It demonstrates that studying sulba sutra texts involves familiarity with the religious practices, rituals, and beliefs of the Vedic period.
;

यच्छोषपाकाभ्यां प्रतिह्सेत् पुरीषेण तत्संपूरयेत् पुरीषस्या – नियतपरिमाणत्वात्।। 2.60।।

The loss in the required measure of the bricks due to drying and burning is to be compensated with the purusa (the loose earth)at the time of placement as there is no fixed size of purusa. (B.S.2.60)

इष्टकाचिद्वा अन्ययोऽग्निः पशुचिदन्य इत्येतस्माद् ब्राह्मणात्।। 2.40।।

On the basis of the Brahmana- which says that one Agni is constructed with bricks and the other one is constructed with animals-(it is proved that the Agni should be constructed with bricks only not with other material). (B.S.2.40)

समचतुरस्त्राभिरग्निं चिन्वीत दैव्यस्य च मानुषस्य च व्यावृत्या इति मैत्रायणीयब्राह्मणं भवति।। 3.10।।

Keeping in view the separation of divine and human, he should construct the Agni with square bricks only', says the Maitrayaniya Brahmana. (B.S.3.10)

आग्नीध्रीयागारस्य पार्श्वमानी पञ्चारत्निः।। 1.103।।

The side of the agnidhriyagara (the hall for the protection of the agnidhra – fire) is five aratnis. (B.S.1.103)

वितृतीया वेदिर्भवतीति पैतृक्या वेदे र्विज्ञायते।। 1.81।

The paitrki vedi is to be constructed with a third of the side of the Mahavedi that is the Sruti regarding the paitrki vedi. (B.S.1.81)

The excerpts from the Baudhayana Sutras provide valuable insights into the architectural principles governing the construction of Vedic ritualistic structures. Emphasizing the exclusive use of bricks for Agni construction, the sutras underscore the significance of material choice in architectural design (B.S.2.40). The compensation for brick loss through the loose earth during placement reflects a pragmatic approach to construction challenges (B.S.2.60). Reference to the Maitrayaniya Brahmana advocates for the use of square bricks in Agni construction, suggesting a geometric precision in architectural design (B.S.3.10). Specifications for the agnidhriyagara dimensions and the proportionate construction of the paitrki vedi further highlight the meticulous planning and mathematical considerations embedded in Vedic architectural practices (B.S.1.103, B.S.1.81). Hence it is evident that the principles of Sulba geometry serve as a valuable foundation for understanding and learning architecture. Amma (1999) also quoted "The constructions in the Sulba Sutras are concerned their rightful legatee is the science of architecture."

रथचक्रचितं चिन्वीतेति विज्ञायते।। 3.179।।

He is to construct the rathacakracit (the Agni in the form of a chariot –wheel, says the Sruti. (B.S.3.179)

(अथापरम्। वयसां वा एष प्रतिमया चीयते यदग्निरिति।। 3.8।।

This Agni is constructed in the shape of the birds', says the second Brahmana. (B.S.3.8)

मण्डलमृषभं विकर्णीमतीष्टकासु लक्ष्माणि प्रतीयात्।। 2.43।।

By the expressions used in the ritual literature in connection with the construction of the Agni such a : 'mandalestaka upadadhati,'rsabhestaka upadadhati, 'vikarnimupadadhati,' we are to understand signs of that form (a circle, a bull, a woman without ears)drawn on the bricks not bricks of those shapes. (B.S.2.43)

कङ्कचित् एतेनात्मा पुच्छं च व्याख्यात्म् ।। 3.136।।

Thereby the body and the tail of the Kankacit are considered to be explained. (B.S.3.136) (The altar constructed in the form of a kanika means kite)

The Baudhayana Sutras provide insights into the artistic dimensions of Vedic ritual constructions. Directives to shape Agni altars like a chariot-wheel (B.S.3.179) or birds (B.S.3.8) demonstrate symbolic representations. Additionally, expressions like 'mandalestaka upadadhati' (B.S.2.43) suggest the use of symbolic signs on bricks, highlighting a nuanced artistic language in the construction process. The mention of a Kankacit altar (B.S.3.136), likened to a kite, further illustrates the fusion of artistic creativity with religious practices, showcasing the rich artistic dimensions within Vedic rituals. Hence, the geometric designs and altars described in the Sulba Sutras have artistic and symbolic significance. Interpreting these aspects involves an understanding of art and symbolism. In essence, the Sulba Sutras represent a holistic approach to knowledge that includes multi-disciplines.

- **Use of Real Objects in Learning:**

Several types of materials and objects were used in constructing the geometrical figures, such as:

1. Tilas or Sesame Seeds:

ऊर्ध्वप्रमाणाभ्यासं जानोः पञ्चमस्य चतुर्विंशेनैके समामनन्ति।। 2.13।।

According to some teachers of the rituals, a vertical increase of the twenty-fourth part of a fifth of a janu (9 tilas) is required. (B.S.2.13)

The sutra (B.S. 2.13) mentions the requirement of a vertical increase of the twenty-fourth part of a fifth of a janu (9 tilas). This implies the use of Tilas or Sesame seeds for measurement in constructing the altars.

2. Bricks and Pebbles:

मन्त्रव्यतिरेकेऽक्ताः शर्कराः संधिषूपदध्यात्।।2.47।।

In case if the number of the mantras exceeds that of the bricks, then the pebbles anointed with clarified butter should be placed in the joints of bricks. (B.S.2.47)

न स्वयमातृण्णां स्वयंचितावुपदध्यात्।। (B.S.2.57)

In the svaymciti (the citi where svayamatrnna pebbles are employed), the svayamatrnna (self-perforated pebbles) should be employed so as it is not covered by the bricks. (B.S.2.57)

The sutra (B.S. 2.47) discusses the use of bricks in altar construction. If the number of mantras exceeds the number of bricks, pebbles anointed with clarified butter should be placed in the joints of the bricks. In B.S. 2.57, the use of "svayamatrnna" (self-perforated pebbles) in the Svaymciti was mentioned. These pebbles were employed, and it's specified that they should not be covered by the bricks. This indicates the use of bricks and pebbles as construction materials.

3. Cane or Bamboo:

यावान्पुरूष ऊर्ध्वबाहुस्तावदन्तराले वैणोश्छिद्रे करोति ।। 3.13 ।।

(The expert) makes two holes at the ends of a cane such that the distance between them is equal to the measure of a purusa (yajamana) with uplifted arms. (B.S.3.13)

प्राग्वंशःषोडशप्रक्रमायामो द्वादशव्यासः । अपि वा द्वादशप्रक्रमायामो दशव्यासः ।। 1.88 ।।

The pragvamsa has the length of sixteen prakramas and the width of twelve prakramas , or alternatively, it has the length of twelve prakramas and the width of ten prakramas. (B.S.1.88)
*(The hall with bamboo ridge directed to the east is called pragvamsa. It is constructed to the west of the sadas (the hall of the priest). It measures 16*12or 12*10prakramas.(pp-319)*

The B.S. 3.13 mentioned the use of a cane with two holes at the ends. The distance between these holes was equal to the measure of a purusa (yajamana) with uplifted arms. This cane may be used as part of the altar structure, possibly for measurement or alignment. The B.S. 1.88 refers to the 'pragvamsa' hall, which is constructed using bamboo. It mentions specific dimensions for the hall, indicating the use of bamboo as a primary material.

4. Bricks of Clay Mixed with Ashes:

एवमस्य मन्त्रवती चितिक्लृप्तिः ।। (B.S.2.80)

In this manner (by making bricks of clay mixed with ashes from the ukha), the construction of the citi of the yajamana becomes mantravati (purified by the mantras). (B.S.2.80)

The fifth passage, it discusses the construction of the citi of the yajamana using bricks made of clay mixed with ashes from the ukha. This indicates the use of clay and ashes as materials for constructing the altar.

Hence, it can be said that the construction of geometrical figures embedded in fire altars was done using real objects such as sesame seeds, bricks, pebbles, clay, ashes, clarified butter and bamboo etc. The use of these kinds of objects in mathematical practices was the most primitive method (Amma, 1997).

➢ **Learning was not External but a part of daily life:**

व्यायाममात्री भवतीति गार्हपत्यचितेर्विज्ञायते ।। 2.61 ।।

The altar of the garhapataya is of one square vyayama measure, this is known from the sruti. (B.S.2.61)
(The garhapataya fire has an important place.it is called so because it is the master of the house-holder or it belongs to the house –holder) pp-315

ततश्चयतुर्षु हविर्धानम् । तददशकं द्वद्वादशकं वा ।

मानयोगस्तयोर्व्याख्यातः ।। 1.96 ।।

From this s(sadas) at a distance of four prakramas or padas, the havirdhana should be constructed in the form of a square measuring ten or twelve prakramas/padas; the measurement of the sadas and havirdhana has been explained I the rule 1.42 . (B.S.1.96)
*(The hall was constructed for storing the material required for the performance of the sacrifice. It is square shaped measuring 10*10 or 12*12 square prakramas) pp-315*

एतेन मार्जालीयो व्याख्यात ः।। 1.104 ।।

Similarl,y the marjaliyagara is explained. (B.S.1.104)

The location of the hall of the marjaliya is on the southern sector of the mahavedi and its size is the same as that of the agnidhriyagara .The utensils used in the sacrifice are cleaned in this hall. It also houses the marjaliya dhisnya.

The B.S.2.61 describes the dimensions of the *Garhapataya* altar. It had a central role in domestic Vedic rituals (Kramrisch,1962). It is said to be of one square vyayama measure. B.S.1.96 discussed the construction of the *Havirdhana*, which is a hall used for storing materials required for sacrifices. It is specified that the hall should be constructed at a particular distance and in the form of a square with specific dimensions (ten or twelve prakramas/padas). B.S.1.104 refers to *Marjaliyagara*, a hall used for cleaning utensils and housing the marjaliya dhisnya, a part of Vedic rituals. It is located in the southern sector of the *Mahavedi* and is described as having the same size as the *Agnidhriyagara*. The precise measurements and geometrical considerations in constructing these altars reflect the integration of mathematics into the practical aspects of Vedic rituals. The integration of mathematics into spiritual life underscores the importance of precision and mathematical knowledge in the everyday practices of the common people during the Vedic period. It also shows how mathematics was not treated as an external academic discipline but as a practical tool for spiritual and religious purposes.

- **Learning by Doing:**

अपि वा गार्हपत्याहवनीययोरन्तरालं पञ्चधा षोढा वा संभुज्य सप्तमं वा भागमागन्तुकमुपसमस्य समं

त्रैधं विभज्य पूर्वस्मादन्ताद् द्वयोर्भागयोर्लक्षण करोति। गार्हपत्याहवनीयोरन्तौ नियम्य लक्षणेन

दक्षिणापाम्य लक्षणे शङ्कूं निहन्ति। तद्दक्षिणाग्नेरायतनं भावति।। 1.68 ।।

Or else having divided the cord measuring the space between the ahavaniya and garhapatya either into five or six parts; having added a sixth or seventh part (as the case may be); and having divided the whole (thus obtained)into three parts; after measuring from the east end make a mark after the two parts; having fixed the slings of the cord at the sankus of the garhapatya and the ahavaniya, stretch the cord with the marks towards the south and fix a sanku where the mark touches the ground; this is the location of the daksinagni. (B.S.1.68)

अपि व प्रमाणं पञ्चमेन वर्धयेत्। तत्सर्व पञ्चधा संभुज्या परस्मादन्ताद् द्वयोर्भागयोर्लक्षणं करोति।

पृष्ठ्यान्तयोः पाशौ प्रतिमुच्य लक्षणेन दक्षिणापायम्य लक्षणे शङ्.कु निहन्ति। तद्दक्षिणाग्नेरायतनं

भवति।। 1.69 ।।

Or else, increase the measure (the distance between the ahavaniya and the garhapatya) by its fifth; having divided the whole into five parts make a mark at the end of two parts measuring from the western end; having fixed the slings at the ends of the prsthya stretch the cord by the mark towards the south and fix a sanku at the point where the mark touches the ground. This is the place (centre) of the daksinagni .”(B.S.1.69)

The B.S. 1.68 and B.S. 1.69 described alternative methods to determine the location of the *Daksinagni*, a southern fire altar between the *Ahavaniya* and *Garhapatya* altars. The specific method chosen was depending on the particular ritual and the preferences of the ritual performer. The procedure involves several steps such as dividing the chord, adding a part, further division, the measurement from the east or west, fixing and stretching the chord and then fixing the shanku.

These sutras directly engage the performer in the ritual process as he determines the location of the *Daksinagni* himself. This approach aligns with the experiential learning approach, where individuals gain knowledge and skills through direct experience and active participation in an activity (Kolbe, 1984). The sutras also offered alternative methods for locating the *Daksinagni*, allowing room for experimentation. Learners might try different approaches to see what works best in different ritual contexts. This trial-and-error process is a key aspect of learning by doing, where individuals refine their skills and knowledge through practical experience and adaptation (Sosna, et al., 2010). Furthermore, the sutras are highly contextualized, addressing a specific aspect of Vedic ritual practice. Performers adapted these instructions to the specific needs of each ritual, a form of context-based learning. Understanding and responding to specific contexts is fundamental to the 'learning by doing' approach.

Hence, these sutras reflect a learning approach that combines theoretical knowledge with practical application. They encourage individuals to actively participate in the rituals and apply their understanding in a real-world context. This aligns with the idea that true mastery and understanding often come through direct experience and practical engagement.

- **Learning without Burden:**

प्रउगचितं चिन्वीतेति।। 3.161 ।।

The sacrificer is to construct the praugacit (an altar of the shape of an isosceles triangular). (B.S.3.161)

यावानग्निःसारात्नप्रादेशस्तावत्प्रउगं कृत्वा तस्यापरस्याः करण्या द्वादशेनेष्टकास्तदर्धव्यासा : कारचेत्।।

3.162 ।।

Having drawn a prauga equal to the seven-fold Agni together with the two aratnis and one pradesa (i.e.7.5squares purusas),he (the expert) is to make bricks whose length is equal to the twelfth part of the western side of the pruga and the width is equal to half of the length. (B.S.3.162)

तासामर्ध्या पाद्याश्च ।।3.163 ।।

The ardhyas (half-bricks) and padyas (quarter bricks –dirghapadyas ,sulapadyas) of these brhatis are to be made.(B.S.3.163)

तासां हे अर्धेष्टके बाह्मा सविशेषे चुबुक उपदध्यात्।। 3.164 ।।

From amongst these bricks, he is to place two ardhyas (half –bricks) in the apex of the prauga in such a manner that their hypotenuse is turned towards the outside. (B.S.3.164)

अध्यार्श्चान्तयोः ।। 3.165 ।।

And ardhyas (half-bricks)on both sides (the southern as well as northern). (B.S.3.165)

शेषमग्निं बृहतीभिः प्रच्छादयेत्। अर्धेष्टकाभिः संख्यां पूरयेत्।।3.166 ।।

He is to cover the remaining part of the Agni with the brhatis and fulfil the required number with the ardhyas (half-bricks). (B.S.3.166)

अपरस्मिन्प्रस्तारेडपरस्मित्रनीके सप्तचत्वारिशत्पादेष्टका व्यतिष्क्ता उपदध्यात्।। 3.167 ।।

In the second layer, he is to place forty-seven quarter bricks (sulapadyas) in the western front in such a manner that these are joined with each other. (B.S.3.167)

चुबुक एकाम् ।। 3.168 ।।

(He is to place) one (sulapadya) son the apex. (B.S.3.168)

दीर्घे चेतरे चतस्त्रः स्वयमातष्णावकाश उपदध्यात्।।3.169 ।।

He is to employ two dirghpadyas and two others (i.e.sulapadyas) in place of the svayamatrnna(i.e.the centre of the altar). (B.S.3.169)

अध्यार्श्चान्तयोः ।। 3.170 ।।

He is to place the ardhyas (half –bricks) on the edges (the southern and the northern sides). (B.S.3.170)

शेषमग्निं बृहतीभिः प्राचीभिः प्रच्छादयेत्। अर्धेष्टकाभिः संख्यां पूरयेत्।। 3.171 ।।

➢ *He is to cover the remaining part of the Agni with the brhatis directed towards the east and he is to complete the required number with the ardhyas. (B.S.3.171)*

त्रिशत्पदानि प्रक्रमा वा पश्चात्तिरश्ची भवति षट्त्रिंशत्प्राची चतुर्विंशति : पुरस्तान्तिरश्चीति

महावेदेर्विज्ञायते। मानयोगस्तस्या व्याख्यातः ।।1.90 ।।

The *western tiryanmani is thirty padas or prakramas long, the praci(east-west line) thirty –six , the eastern tiryanmani twenty-four ' this is the Sruti regarding the measure of the mahavedi ; the method for its construction has been explained (rule1.42) (B.S.1.90)*

आहवनीयात्षढप्रक्रमान्महावेदिः ।।1.91 ।।

The mahavedi is six prakramas away from the ahavaniya. (B.S.1.91)

The above sutras text delineates meticulous religious rituals associated with Vedic sacrificial ceremonies. The construction of a praugacit, an altar shaped as an isosceles triangle (B.S.3.161), involves specific dimensions and the creation of bricks, where the placement of ardhyas (half-bricks) and padyas (quarter bricks) is detailed (B.S.3.163). The arrangement of bricks, including their orientation and alignment, is outlined for the altar's

layers (B.S.3.164-171). Additionally, the text provides measurements for the mahavedi, the ritual space, emphasizing the precision in the placement and dimensions of the religious constructs (B.S.1.90-91).
In these texts, religious rituals and mathematics are intricately woven together. The learners, often participants in these rituals, were not burdened by abstract mathematical concepts. Instead, they were actively engaged in applying these geometric principles in practical ways to construct precise and sacred altars. This integration of mathematics into religious practices imparts a profound sense of purpose and relevance to the learning process. Learners were motivated by their deep desire to contribute to their community's customs and traditions through the construction of these sacred structures. This dynamic illustrates how the Sulba Sutras epitomize mathematics learning without burden. The learning experience was imbued with meaning, tied to cultural practices, and is far from the conventional burdensome perception of mathematics education. It underscores the idea that when mathematics is integrated into real-life contexts and traditions, it can become a source of motivation, engagement, and deep understanding, making it a joyful and meaningful learning experience (Khunyakari, 2023).

- **Deductive Reasoning Approach:**

दीर्घचतुरस्त्रस्याक्ष्णयारज्जुः पार्श्वमानी तिर्यङ्मानी च यत्पृयग्भूते कुरूतस्तदुभयं करोति । ।1.48 । ।

The diagonal of an oblong produces an area which is equal to both the areas produced separately by the parsvamani and the triynimani of the oblong .(B.S.1.48)

The sutra B.S. 1.48 starts with the premise that the diagonal of an oblong produces a certain area. From this principle, it deduces that this area is equal to the sum of the areas produced separately by the parsvamani (longer side) and the triynimani (shorter side) of the same oblong. This is a clear example of deductive reasoning.

त्रिकचतुयोर्द्वादशिकपाञ्चकयोः पञ्चदशिकाष्टिकयोः सप्तिकचतुर्विंशिकयोर्द्वादशिकपञ्त्रिंशिकयोः

पञ्चदशिकषट— त्रिंशिकयोरित्येतासूपलब्धिः । ।1.49 । ।

The examples of this theorem can be seen in those oblongs the tiryanimanis and the parsvamanis are respectively 3 and 4 ;12 and 5; 15 and 8; 7 and 24; 12 and 35; 15 and 36. (B.S.1.49)
The sutra B.S. 1.49 provides examples to support the deductive reasoning presented in the sutra B.S.1.48. Showing specific pairs of measurements for *Tiryanimanis* and *Parsvamanis*, reinforces the deductive principle that the diagonal's area is equal to the sum of these areas.

चतुरस्त्रं मण्डलं चिकीर्षन्नक्ष्णयार्ध मध्यात्प्राचीमभ्यापातयेत् यदतिशिष्यते तस्य सह तृतीयेन मण्डलं

परिलिखेत् । ।1.58 । ।

If *you wish to transform a square into a circle, at the centre of the square, fix a cord equal to half of the diagonal of the square and draw an arc from the north-east corner towards the east-west line; draw a circle together with the third part lying outside the square. (B.S.1.58)*

The B.S. 1.58 provides deductive instructions for transforming a square into a circle. It starts with the premise that a cord equal to half of the square's diagonal is used. From this premise, it deductively instructs practitioners on how to draw a circle, including the size and position. This is a practical application of deductive reasoning.

अपि वा पञ्चदश भागान्कृत्वा द्वावुद्धरेत्। सैषानित्या चतुरस्त्रकरणी । ।1.60 । ।

Or else, divide the diameter into fifteen parts and remove two parts; the side of the square, thus obtained is approximate.(B.S.1.60)

The B.S. 1.60 offers an alternative method for approximating the side of a square by deductively instructing practitioners to divide the diameter into fifteen parts and remove two parts. This is a practical application of deductive reasoning to achieve an approximate result.

प्रमाणं तृतीयेन वर्धयेत् तच्चतुर्थेनात्मचतुस्त्रिंशोनेन । ।1.61 । ।

Increase the measure of the square by its third and this third by its fourth less the thirty–fourth part of this fourth.(B.S.1.61)

The B.S. 1.61 deductively provides a method for increasing the measure of a square in a step-by-step manner, starting with known fractions. It uses deductive logic to derive the final result.

तृतीयकरण्येतेन व्याख्याता। नवमस्तुभूमेर्भागो भवतीति । ।1.47 । ।

Thereby is explained the trtiyakarani (1/√3; it (the area produced by the trtiyakarani) is the ninth part of the area produced by the trikarani.(B.S.1.47)

B.S. 1.47 sutra deductively explains the relationship between the areas produced by the trtiyakarani and the trikarani. It starts with the premise and deductively derives that the former is the ninth part of the latter. It can be seen that the above sutras start with known principles and systematically guide practitioners through the process of achieving specific geometric results. They are meticulously detailed and precise in their instructions, reflecting a deductive approach to ensure that rituals are conducted accurately. In conclusion, the sulba sutras clearly demonstrate a deductive reasoning approach by providing specific conclusions and instructions based on established principles and premises.

➢ **Practical Applications of Theories:**

दीर्घचतुरस्त्रं समचतुरस्त्रं चिकीर्षस्तिर्यङ्मानीं करणीं कृत्वा शेषं द्वेधा विभज्य पार्श्वयोरूपदध्यात्।
खण्डमावापेन तत्संपूरयेत्। तस्य निर्हार उक्तः।।1.54।।

If you are desirous of converting an oblong into a square, cut off a square from the oblong by taking the tiryanmani of the oblong as its side; divide the remaining portion into two parts and adjust them along the two sides of the square. Complete the square by adding a smaller square in the corner. Deduct the added portion from the resultant figure. (B.S.1.54)

The B.S. 1.54 dealt with converting an Oblong into a Square by taking following steps:

- Cut off a square from the oblong by using the 'tiryanmani' (the shorter side) of the oblong as its side.
- Divide the remaining portion into two parts.
- Adjust these two parts along the two sides of the square.
- To complete the square, add a smaller square in the corner.
- Deduct the added portion from the final figure.

दीर्घचतुरस्त्रं समचतुरस्त्रं चिकीर्षस्तिर्यङ्मानीं करणीं कृत्वा शेषं द्वेधा विभज्य पार्श्वयोरूपदध्यात्।
खण्डमावापेन तत्संपूरयेत्। तस्य निर्हार उक्तः।।1.54।।

If you wish to transform a square into a ubhayatah prauga (a rhombus), make an oblong of twice the desired area and fix a sanku at the middle of the eastern side; having fixed at the sanku two cords, stretch the cords towards the middle of the southern and the northern sides; remove the portion that lies outside the cords; similarly the western prauga is explained.(B.S.1.57)

The B.S. 1.57 details the procedure for transforming a Square into a Rhombus (Prauga) which involves the following steps:

- Create an oblong with an area that is twice the desired area of the rhombus.
- Fix a "sanku" (a term that refers to a point) in the middle of the eastern side of the square.
- Attach two cords to the sanku.
- Stretch these cords towards the middle of the southern and northern sides.
- Remove the portion of the square that lies outside these cords.
- A rhombus is created.

चतुरस्त्रं मण्डलं चिकीर्षन्नक्ष्णयार्धं मध्यात्प्राचीमभ्यापातयेत् यदतिशिष्यते तस्य सह तृतीयेन मण्डलं परिलिखेत् ।।1.58।।

If you wish to transform a square into a circle, at the centre of the square, fix a cord equal to the half of the diagonal of the square and draw an arc from the north-east corner towards the east-west line; draw a circle together with the third part lying outside the square. (B.S.1.58)

The procedure for transforming a Square into a Circle was described in B.S. 1.58 involving the following steps:

- At the centre of the square, fix a cord equal to half the diagonal of the square.
- Draw an arc from the north-east corner towards the east-west line.
- This arc should result in a circle, including the third part that lies outside the original square.

मण्डलं चतुरस्त्रं चिकीर्षन् विष्कम्भमष्टौ भागान्कृत्वा भागमेकोनत्रिंशधा विभज्याष्टाविंशतिभागानुद्धरेद् भागस्य च षष्ठमष्टमभागोनम्।। 1.59।।

If you wish to transform a circle into a square, having divided the diameter into eight parts and one of these eight parts *into twenty-nine parts, remove twenty –eight parts; remove the sixth part of the remaining one part less the eighth part of the sixth part.(B.S.1.59)*

The B.S. 1.59 instructs about transforming a Circle into a Square:
- Divide the diameter of the circle into eight parts.
- Take one of these eight parts and further divide it into twenty-nine parts.
- Remove twenty-eight parts from this division.
- Remove the sixth part of the remaining part but leave out the eighth part of the sixth part.
- What remains should be the side of a square that you can form from the original circle.

These sutras embody the inherent principle of practical applications of geometrical theories. They not only talk about geometrical concepts but also emphasize their immediate and tangible application in religious ceremonies. It is supported by Divakaran & Divakaran (2018) as well. The steps to transform shapes, such as converting an oblong into a square or a square into a circle, are not abstract mathematical exercises but rather practical guidelines that could be applied in diverse contexts. The focus on creating altars and sacred structures using precise geometric transformations demonstrates the immediate relevance of mathematical theory in practical scenarios. This approach underscores the practicality of ancient mathematical education and highlights the notion that learning geometry and mathematics was not merely theoretical but deeply rooted in their real-world applications, reflecting the integral connection between theory and practice in the study of geometrical theories.

Conclusion:

The analysis of the Sulba Sutras reveals a sophisticated pedagogical approach to mathematics during the Vedic period. The sutras employ a lyrical and mnemonic style, demonstrating an early recognition of the importance of engaging and preserving knowledge through memorable formats. By using real-world objects and practical tools such as cords, slings, and sankus, the Sulba Sutras emphasize a hands-on, constructivist learning approach that encourages active participation and problem-solving skills. The integration of geometric principles into the construction of Vedic ritualistic structures showcases a seamless connection between theory and practice, providing learners with meaningful contexts for applying mathematical concepts. Moreover, the sutras underscore the cultural relevance of mathematics, portraying it not as an isolated academic discipline but as an essential tool deeply intertwined with spirituality and everyday practices. This pedagogical richness in the Sulba Sutras challenges conventional notions of mathematics education, presenting it as a joyful, culturally embedded, and holistic learning experience.

References:

1. Amma, T. S. (1999). *Geometry in ancient and medieval India*. Motilal Banarsidass Publ.
2. Divakaran, P. P., & Divakaran, P. P. (2018). Vedic Geometry. *The Mathematics of India: Concepts, Methods, Connections*, 43-71.
3. Dutta, A. K. (2016). Was there sophisticated mathematics during the Vedic Age. *An anthology of disparate technical thoughts at a popular level"(ed. A. Chaudhuri), ISIREA*.
4. Dutta, A. K., & Sriramb, M. S. Mathematics and Astronomy in India before 300 BCE. https://www.ms.uky.edu/~sohum/ma330/files/DuttaSriramarticle.pdf
5. Filliozat, P. S. (2004). Ancient sanskrit mathematics: An oral tradition and a written literature. In *History of science, history of text* (pp. 137-157). Dordrecht: Springer Netherlands. Gupta, A. (2013). *Unfolding Faith: A Journey to the Kumbh*. Partridge Publishing.
6. Glucklich, A. (2008). *The strides of Vishnu: Hindu culture in historical perspective*. Oxford University Press.
7. Jarvis, D., & Naested, I. (2012). *Exploring the math and art connection: Teaching and learning between the lines*. Brush Education.
8. Joseph, G. G. (2001). The Crest of the Peacock: Non-European Roots of Mathematics. *NEXUS NETWORK JOURNAL*, *3*(2).
9. Kappraff, J. (2001). *Connections: The Geometric Bridge Between Art & Science* (Vol. 25). World Scientific.Khunyakari, R. (2023). Learning without Burden. Routledge.
10. Khunyakari, R. (2023). Learning without Burden.
11. Kolbe, D. A. (1984). Experiential learning. *New Jersey, Eaglewood Cliffs*.
12. Kramrisch, S. (1962). The Triple Structure of Creation in the Ṛg Veda. *History of Religions*, *2*(1), 140-175.
13. Seidenberg, A. (1961). The ritual origin of geometry. *Archive for history of exact sciences*, *1*, 488-527. Sosna, M., Trevinyo-Rodríguez, R. N., & Velamuri, S. R. (2010). Business model innovation through trial-and-error learning: The Naturhouse case. *Long range planning*, *43*(2-3), 383-407.
14. White, M. D., & Marsh, E. E. (2006). Content analysis: A flexible methodology. *Library trends*, *55*(1), 22-45.