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## Javanese Ethnomathematics in Building Symbolic Systems and Visual Aesthetics

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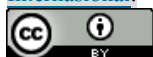
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### ABSTRACT

Javanese ethnic cultural works are generated from its philosophical thought, yet there is no local method used as a basis for approaching its aesthetic objects. Petungan, a practice of ethnomathematics, has been employed by premodern Javanese society to calculate all aspects of life. This qualitative study aims to investigate Javanese ethnomathematics, interpreting the value and meaning of numbers in the creation of symbols and visual forms. This research employing an ethnographic approach with analytical methods to find aesthetic principles from the logical structure of Javanese philosophy in building visual form. The results show that numbers are directly involved in constructing visual symbols and aesthetics in architectural motifs or batik patterns. Numbers are connected with belief values, character, cosmic elements, and metaphysics. Numbers are part of human life related to the cosmic system. The number five (sacred five) is used as a basis for calculations in petungan, serving as a measured guideline for determining life safety and prosperity. The number five, derived from the philosophy of keblat papat lima pancer, is a symbol that represents and unifies all cosmic elements: humans, nature, and their creator. The numbers two, three, four, and five manifest in visual symbols forming basic geometric shapes. These geometric patterns are arranged aesthetically through concepts of geometric transformations, reflection, translation, dilation, and rotation. Conclusion: The Javanese numerical system has a solid structure in creating decorative visual forms. When combined with petungan, there is potential to develop methods for calculating and building compositions that meet Javanese aesthetic ideal ratios.

## INTRODUCTION

Javanese Ethnomathematics is a field of study that examines the relationship between mathematics and Javanese culture. The term "ethno" refers to a broad context encompassing social, cultural, linguistic, behavioral, mythological, and symbolic aspects. The root "mathema" means explaining, knowing, understanding, and engaging in activities such as coding, measuring, classifying, summarizing, and modeling. The suffix "tics" originates from "techne," meaning technique. Ethnomathematics journals discuss how Nusantara cultural works in the form of traditional houses, batik motifs, ulos fabrics, traditional musical instruments, traditional music, dance, and the determination of traditional ceremony dates are calculated using mathematical principles. The study only identifies and proves that cultural products can be calculated using mathematical science. Javanese culture actually has its own way of thinking in using mathematics called "petungan." Petungan means counting, so Javanese petungan is an application of ethnomathematics in everyday life. Petungan involves deep consideration and reasoning, containing the concepts of calculation, interpretation, problem-solving, summarization, and decision-making. Javanese culture with its mystical-religious philosophy has a way of life that is guided by three fundamental philosophies: ngudi kasampurnan (the pursuit of perfection), sangkan paraning dumadi (awareness of human origin), and manunggaling kawula gusti (the unity of humans with God). The achievement of perfect life is the most rational reason for the emergence of Javanese petungan. Petungan is an effort to make thorough calculations and planning holistically in all aspects of life. The primary goal of petungan is to achieve harmony between humans, nature, and God. Petungan is used to determine the position of house doors, well locations, good times for building houses, suitable times for activities, predicting matches, personalities, etc. Where good times include hours, days, market days (Javanese birth days),

months, letters, environmental conditions like stars, moon phases, etc., each having its own numerical value. The Javanese petungan system also calculates the ideal proportions of Javanese buildings, where good proportions are determined from the remainder of calculations linked to predictions of fate and fortune. This aspect is one reason why Javanese ethnomathematics is considered an ancient science. Because it is considered non-scientific. This study examines the basic logical structure of Javanese philosophy through petungan. It explores the meaning and pattern of all elements used in Javanese petungan, such as numbers, birth dates, market days, personalities, special numbers, market days, and other elements connected with petungan like cosmology. How does the relationship between philosophy, petungan, and Javanese ethnomathematics contribute to building symbols and forms in producing aesthetics according to Javanese cultural thought? Petungan or ethnomathematical activities are one evidence showing there is an ancient culture and intelligence in understanding life knowledge. Unique Javanese philosophical thinking in producing petungan and proportion systems need to be explored, especially in linking rational reasoning through mathematical concepts with seemingly irrational elements. This study formulates three research question: what is the role and meaning of numbers in Javanese culture? What is their relevance to belief? And how do numbers and Javanese ethnomathematical concepts play a role in shaping visual creation pattern?

In several journals related to Javanese ethnomathematics through petungan systems, common studies examine mathematical concepts and calculation processes for determining good days. Research on Javanese ethnomathematics focusing on visual forms usually only connects the results of cultural products such as traditional houses, tools, batik motifs calculated using mathematical science. The proportions of Javanese petungan systems are implied in ancient

texts like *serat centhini* (a Javanese manuscript), *primbon* (a Javanese book of omens), and *kawruh kalang* (a Javanese book of knowledge), which provide rules for all aspects of life including determining ideal proportions according to Javanese perspectives in building houses. These three texts have been compiled and reconstructed by Josef Prijotomo in his dissertation titled "*Sistem Petungan dalam Arsitektur Jawa*." His book discusses construction *atap* (roof), number of frames, ratio between roof size and building size, pillar height, and ratio between building length and width according to room function. Atmadi's dissertation measured *candi* proportions while Moedjijono's journal presented norms but did not clarify whether these norms were geometric like golden section nor confirmed whether presented formulas were norms or guidelines (Prijotomo, 1995). Djoko Wijono and Rahmad Wondamaiseno applied *petungan* in finding proportions for *Limasan* Javanese houses in *Kampong Srontongan* while Irwan Harnoko used *petungan* for calculating two-dimensional *wayang* character layout proportions concluding that *petungan* could serve as DKV Javanese method system.

## **METHODS**

The study on Javanese ethnomathematics to find the system of symbols and visual aesthetics based on Javanese perspectives and philosophy is a qualitative research using ethnographic and ethnological approaches. The analytical method is used to identify, link, analyze, and interpret the data. The synthetic method is employed to draw conclusions from the data and facts. Primary data collection involves a literature study of ancient texts such as *serat centhini*, *kawruh kalang*, *naskah kawruh kambeng*, *petungan in karuh kalang kapatihan*, and *primbon* books, particularly to understand Javanese numerology such as *sabda pandita*, *sabda nata*, *atassadhur adammakna*, *qomarrulsyamsi adammakna*, and *shahdatsathir adammakna*. Books related to Javanese life philosophy such as Javanese cosmology,

metaphysics, *sangkan paraning dumadi*, *ngudi kasampurnan*, and *mancapat* are also studied. Interviews with knowledgeable sources who understand the basics of Javanese *petungan* and Irwan Harnoko, author of the journal on Javanese DKV *petungan*, are conducted. Secondary data are obtained from dissertations, books, and journals related to the topic. This research focuses on revealing philosophy, meaning, and values with a cultural approach because a deep holistic understanding from the development of past knowledge, such as calculations, cosmology, and cultural philosophy, serves as a basis for living and creating ethnic cultural works through art, *batik motifs*, houses, etc. The values of Javanese wisdom should be preserved to sustain relevance in the present and future. The lifestyle and behavior from Javanese philosophy in achieving perfection and safety in life, such as respecting nature, tolerance among humans, mutual assistance, and consensus, are behaviors worth maintaining. Education and internalization of cultural values can be pursued in various forms, including introducing cultural products and art. Preserving cultural continuity through the discovery of emerging methods and concepts from local sciences, particularly Javanese, can be used as guidelines for creating local architectural designs, interiors, and furniture that reflect local identity. This will support and align with Sustainable Development Goals in Indonesia. Cultural knowledge is important to remain sustainable because each nation has its own history and ideology. A country should grow and develop according to its cultural values. Cultural identity should emerge and continue to monitor the changing world. If this research continues, there is potential to find a system of proportions from Javanese science used in creating forms of local spirit. Through collaboration with computer science, methods for calculating proportion systems based on Javanese beauty theory can be computerized. Globalization makes the world closer, so the existence of national characteristics and identities must be fought for, one way being

through the emergence of concepts, methods, and theories unique to Javanese that can serve as bases for approaching Javanese objects.

Javanese perspective is required to interpret the meaning of numbers and elements used in Javanese petungan as an application of Javanese ethnomathematics. The methods explain clearly how the author carried out the research. The method must describe the research design clearly, the replicable research procedures, describe how to summarize and analyze the data. The research steps are as follows: 1) analysis of the meaning and philosophy of numbers in Javanese culture, 2) numbers as symbols, 3) numbers having geometric values, 4) numbers forming textual and visual patterns: in sengkalan memet, 5) petungan formulas for calculating building dimensions and determining door positions, 6) numbers and elements in petungan, 7) discussion on numbers as formative symbols and geometry.

## **RESULTS AND DISCUSSION**

### **1. Philosophy and Meaning of Numbers**

Javanese culture, which is mystical and religious, has myths surrounding numbers, particularly odd numbers as reflections of sacred numbers used by its people in daily life. The number one has the meaning sawiji (singular/one/esa). The number two symbolizes two entities of the universe and life that are antagonistic. Dualism in Javanese philosophy is two that are one or *dwi tunggal*. Three represents the existence of humans, nature, and the creator. Four is associated with four cardinal directions. Five is a reflection of four with one controller. The number seven is related to *pitung dina* (seven days), *pitulungan* (help), *bumi langit sap pitu* (seven layers of earth and sky). Seven levels of *tumpang sari* on roofs symbolize humans passing through seven teachings and seven tests in controlling their own good and bad nature. Eight represents *hastabrata*, eight leadership principles from eight life energies: earth, water, fire, wind, sky, sun, stars, moon. The number nine represents

perfection of life depicted by orientation towards nine body holes or *nawa sanga* (Kartika, 2016) (Kartika & Perwira, *Pengantar Estetika*, 2004) ; (Albiladiyah, 1999) Nine symbolism represents nine body holes,  $8+1/9$  becomes *hastagina*. *Nawa sanga* is used symbolically with nine energy channels in human bodies included in patterns of batik motifs.

Numbers in Javanese culture have both meaning and function as symbols. Almost all visual elements created from past cultures are expressions of their perspectives and life philosophies. Mathematics is an exact science with numbers being one of its fundamental components. Generally speaking, ethnomathematics is a way where all visual cultural products are measured through a mathematical approach. Design is related to creating forms; geometric shapes are the basis for all forms. Geometric shapes are measured forms; therefore this research uses numbers and geometric shapes as its components.

### **2. Numbers as Aspects Forming Geometric Patterns**

The number two represents dualism; pre-modern Javanese society has a consciousness that life consists of two opposing elements such as earth-sky, day-night, darkness-lightness, heat-coldness, joy-sorrow. Jacob Sumardjo in "*Estetika Paradoks*" explains that differences exist so that humans can understand without light there would be no darkness; without heat there would be no coldness. Two opposing elements must be accepted equally; they are necessary for life. The number two shows balance; life safety prosperity healing victory fertility emerge from dualism-paradox conditions (Sumardjo, 2014). Dualism in Javanese philosophy is two that are one or *dwi tunggal*. The number two interpreted by Ronald Arya can be seen for several purposes such as showing balance optimization proportionality. Dualism represented by the number two appears in every cultural work created by Javanese people manifesting itself in ornamented carvings and

motifs through paired patterns. The number three as a triangle representing the relationship between humans, nature, and god, Symbolizing harmonious balance. Humans and nature are two distinct elements, with one in the middle as a neutral control point for balance. The number three appears in triangular patterns in ornamentation.

The number three is also connected to the Triloka or Tri Buwana doctrine, which divides the world into three realms. The upper world is where God resides, considered sacred in the Triloka doctrine. The middle world is where humans live, serving as a medium connecting the upper and lower worlds in the Triloka doctrine. The lower world is where spirits reside, considered dark and evil in the Triloka doctrine. The human body is a manifestation of the universe. Humans serve as a cosmic center, oriented towards cardinal points, which are used as references for determining building designs and vertical axes.

The number four represents several aspects: the four cardinal directions (north, south, east, and west), the four elements of the universe (air, fire, earth, and water), and four material elements contained in the earth (gold, copper, iron, and silver). The number four also reflects four nafsu (desires) of humans with four corresponding characters: supiyah-empati and rendah hati, lawamah-tidak memiliki pendirian, mutmainah-rela menanggung beban orang lain, and amarah-ego. Additionally, the number four is linked to the abilities of control and empowerment: rasa (senses), karsa (desires), cipta (mind), and karya (actions). The number four is a dualistic concept but in a plural form; it balances with the number two.

The number five represents the philosophy of Keblat Papat Lima Pancer or Mancapat. Visually depicted as a pyramid where four orientations or four kiblat converge at one point vertically. Four symbols of cosmos with one at the center as their intersection. Four symbols

represent four watak manusia (human characters) such as mutmainah (moderate), lauwamah (unstable), sufiah (wise), and amarah (angry) which can be balanced to form a well-controlled individual. God created humans in five kakang kawah (placenta), adi ari-ari, air ketuban tali pusar (center) representing four body parts of humans—tulang (bones), darah (blood), daging (flesh), plasenta—and one at the center—pusat—representing the womb. Four-five represent five days of pasaran where Kliwon is at the center. Mancapat four-five also forms the basis for neptu calculations used in every calculation as personal elements—sum of the market day value with the day of birth. The number five pattern 4+1, derived from the philosophy of Keblat Papat Lima Pancer or Mancapat, is referred to as the "pola mandala" in the writings of Dharsono Sony. Mandala or Yantra in ancient Indian architecture theory contains meanings related to myths. Mandala is a science of proportions or ratios used to determine the shapes and sizes of building parts (Frick, 1997).

Mancapat based on the orientation of four-five serves as the foundation for creating house layouts, dividing zoning or areas. In residential and urban planning, the palace is the center with four surrounding regions. This is achieved through the use of the number four-five, which also represents the relationship between the king and his subjects (Heinz Frick: 25). The symmetrical layout of vernacular Javanese architecture is a result of transferring Javanese community understanding of the principle of balance into practice to maintain balance between the microcosm (human) and macrocosm (God and the universe).

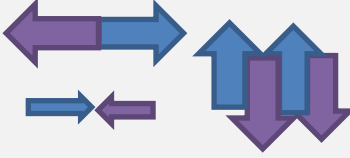
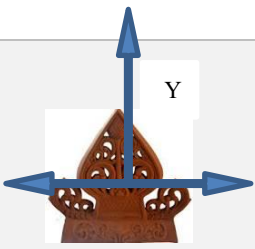
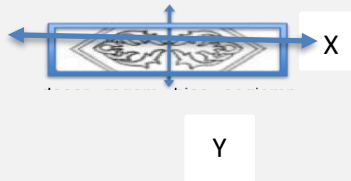
The four cardinal directions each have their own numerical values: 1 represents East, opposite to West which has a value of 3. South has a value of 2, opposite to North which has a value of 4. The number five is located at the center or intersection point of these four cardinal directions. The number five represents perfection and optimization. as







mentioned), where it is noted that there are five journeys from the beginning to the end through other points totaling nine (Arya, 2005).





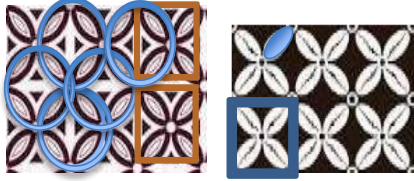
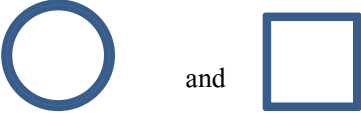

Ethnomathematics in Javanese calculations involves humans and cosmic elements within the universe because it adheres to principles of merging mikrokosmos (human) with makrokosmos (God/universe). The principle of dualism remains while differentiating human positions as creations by their creators. The

existence of God is present in every aspect as a way for humans to feel connected with supreme power. For this reason, numbers are linked with birth dates in Javanese culture reflecting philosophical perspectives where numbers represent various aspects including life cycles like five days pasaran—Wage, Kliwon, Legi, Pahing, Pon—each associated with specific values and characters (Sari, 2008).

Table 1. The Discussion on Numbers, Patterns, and Visual Forms Related to Ethnomathematics

Identification of Numbers, Geometric Patterns, and meaning	Aesthetic Visual Forms	Classification of Application of Ethnomathematics of Mathematical Concepts of Geometry
<p><b>Number Two (2)</b></p> <p><b>Symbol:</b> Dualism, dwi tunggal/dualistic monism</p> <p><b>Meaning:</b> Macrocosm-Microcosm, Male-Female, Sky-Earth, Mountain-Ocean, Bird-Dragon, North-South, West-East, Upstream-Downstream, Life-Die, Upside-Downside</p> <p><b>Pattern:</b> Building paired or opposing patterns.</p> 	 <p><b>Wuwungan Ornament :</b> Positioned as a motif on the roof, symbolizing the union of heaven and earth, two entities.</p> <p><b>Geometric Transformation:</b> Symmetry, Reflection</p> 	<p><b>Geometric Transformation:</b> <b>Symmetry, Reflection</b></p> <ol style="list-style-type: none"> <li>Geometric transformation is the change in position or shape of a geometric object due to translation, reflection, rotation, or scaling.</li> <li>Reflection is the mirroring of a motif with the same distance and size relative to the Y-axis, resulting in unchanged ordinates (y) while changing the position of abscissas (x).</li> </ol> <p><b>Visual Form:</b> The visual motif is arranged in pairs/opposite directions in four orientations (geometric symmetry through reflection in four orientations).</p>
<p>Number Three (3)</p>	<p><b>Tumpal Motif</b></p>	<p>From the intersection of diagonal lines, forming a square, using the concept:</p>

<p>Symbol: Relationship between humans, nature, and God; Mikro-Meta-Makro; Head-Body-Leg; Dunia Atas-Dunia Tengah-Dunia Bawah; Upside-Midle-Downsite; Niskala-Sakala Niskala-Sakala</p> <p>Pattern: Building triangular patterns</p>  <p>Symbol: Humans-God-Nature; Micro-Meta-Macro; Head-Body-Foot; Upper World-Middle World-Lower World; Above-Below; Sacred-Physical Sacred-Physical Cosmology: Personification of Mountains; Tumpal Ornament</p>	  <p>Building a triangle positioned in opposition, as a pattern of three in the concept of a pattern of two, the union of macrocosmos and microcosmos.</p>  	<p><b>Geometric</b></p> <p><b>Transformation:</b> Translasi from a triangle with equal sides.</p> <p>Visual Form: The visual motif is arranged in opposition in two orientations.</p>
<p>Number Four (4)</p> <p>Symbol: Four cardinal directions;N-Black-Tanah; B-Putih; T-Kuning; S-Merah-Api-Tembaga</p> <p>Polarity: North-South-East-West; Black-Red-White-Yellow; Tanah-Api-Udara-Air; Tembaga-Emas-Besi</p> <p>Pattern: Four-sided shapes.</p> <p>U-Hitam-Tanah</p> <p>B-Putih Kuning -Air</p> <p>S-Merah-Api-</p>	 <p><b>Ceplok Ornament:</b> Derived from the intersection of diagonal lines with two different distances (near and far), forming two variations of geometric shapes: rectangle and diamond filled with ceplok motifs.</p>  	<p><b>Geometric</b></p> <p><b>Transformation:</b> Dilatasi or scaling, changing the size of an object with a specific scale factor.</p> <p><b>Geometric Shape:</b> Rectangular</p>

		
<p><b>Number Five (5)</b></p> <p>Symbol/Philosophy: Keblat papat Lima Pancer, representing vertical and horizontal balance.</p> <p><b>Kawung Ornament</b></p>  <p><b>Trumtum Ornament</b></p> 	 <p>and</p>  <p><b>Ragam Hias Kawung:</b> Combination of circles and squares, symbolizing dualistic monism where the essence of God unites with human existence through square shapes. Pattern five is a combination of patterns two and three.</p>	<p><b>Geometric Shape:</b> Circle; Bangun datar lingkaran.</p> <p><b>Geometric Transformation:</b> Translation Reflection, Rotation.</p>
<p><b>Number Zero (0)</b></p> <p><b>Symbol:</b> Emptiness, completeness, essence, totality, perfection of the universe.</p> <p><b>Cosmology</b></p> <p><b>Symbol:</b> orderliness.</p>		<p><b>Geometric Shape:</b> Circle; Bangun datar lingkaran.</p>

The summary table indicates that numbers form visual symbols in the form of basic geometric shapes, motifs. The patterns of these motifs are arranged through mathematical geometric

transformations, including reflection, translation, dilation, and rotation.

## 2. **Petungan in Javanese Architecture**

Petungan appears as a formula in the calculation of architectural proportions in Javanese architecture, represented by the equation  $5n + p$ . The number five is used as a multiplier or divisor. The formula is oriented towards the outcome. The results from the multiplication by five are linked to specific measurements as hopes for safety, prosperity, and good fortune. The number five, known as the "sacred five," is derived from five ancient terms: Esri (good), Kitri (result), Gana (model), Liyu (decay), and Pokah (collapse). Each term has a different value used according to the function and expectations of each room. The sacred five is also used to determine good times for building constructions: Kerta (abundance) with a value of 1, Jasa (strength) with a value of 2, Candi (safety) with a value of 3, Rogoh (theft/death) with a value of 4, and Sempoyong (migration) with a value of 5. The number five is also used to calculate the position of doors by dividing their length by five, resulting in five predictions related to fate or life, known as mancapat. However, there is also manca-sanga, which uses the number nine as the divisor. It can be concluded that Javanese culture has specific proportions and rules to avoid and recommend.

The prehistoric Javanese society has its own logic in placing calculations used in planning their lives. Javanese philosophy understands and acknowledges humans as natural beings who believe that nature and humans influence each other in all aspects related to creation. Numerical values or numbers are connected to birth dates and the cosmos as a way for humans to feel connected with the creator of the universe, manifested in the power that encompasses the universe.

## **CONCLUSION**

The use of numbers in Javanese ethnomathematics is related to belief values, perwatakan, mythology, cosmic elements, and

metaphysics that developed during prehistoric times when society believed in animism and dynamism. At that time, humans felt only a small part of the cosmic power, positioning themselves for harmony. Mythology was used as a way to bridge awareness of divine power with the limitations of understanding natural phenomena and life that were not fully comprehended. The cosmocentric perspective of Javanese philosophy led to ethnomathematics appearing in the form of symbols, numbers, and calculations linked to metaphysical and cosmic elements as a way for humans to feel connected with the absolute.

The number five (sacred five) is always used as a basis for calculations and represents numbers that can symbolize and unify all cosmic elements, including humans and nature, which are manifestations of God. Numbers become essential because through them, a measured resolution or guideline can be obtained for achieving certain determinations. The determination of calculations is an effort by Javanese people to predict the future, avoid bad possibilities, guide towards life safety, and ultimately achieve perfect life by uniting humans with God.

Javanese philosophy is reflected in symbols used to represent cultural expressions and appears in ethnic works. Numbers manifest as visual symbols and basic geometric shapes. Motifs based on dualism from the number two appear in ornamentation patterns. The number three forms the basis for geometric triangles in tumpal motifs. The number four forms the basis for geometric squares used in house layouts. The number five forms the basis for centered square shapes. The number zero symbolizes silence, emptiness, and nothingness for circular shapes. The geometric patterns are arranged according to the concepts of geometric transformation, reflection, translation, dilation, and rotation. Javanese culture also uses sengkalan memet to build texts and images or ornaments.

The interpretation of number meanings related to proportion calculations and the creation of symbols and visual forms that form geometric shapes can be an initial step in finding and developing

possible numbers and proportion formulas in Javanese architecture related to beliefs in petungan. This can lead to discovering new theories about ideal proportions and ratios in local design compositions.

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