Jurnal Cakrawala Pendas
Vol. 11 No. 2, April 2025
DOI: http://dx.doi.org/10.31949/jcp.v11i2.13015

p-ISSN: 2442-7470
e-ISSN: 2579-4442

THE EXPLORATION OF MATHEMATICS CONCEPT ON THE JAVANESE CALENDRICL SYSTEM BY JAVANESE COMMUNITY IN BENGKULU WITHIN ETHNOMATHEMATICS PERSPECTIVE

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Abstract
The Javanese calendrical system is rich in history, philosophy, and math. This ethnomathematical study examined Javanese calendar mathematical concepts and their potential as a learning resource for elementary mathematics. This qualitative research collected data through direct observation, interviews, and literature review. The study used Miles and Huberman's analysis model for data reduction, display, and conclusion drawing. The Javanese calendrical system—Saka Year, Wetonan, lunar cycles, solar cycles, Pasaran, and Wuku cycles—is closely linked to elementary school math concepts. These include time calculations, pattern recognition, cyclical sequences, measurement, whole numbers, fractions, and conversions. The study found how incorporating the Javanese calendar into mathematics education to improve students' contextual understanding and make learning more engaging and culturally relevant. This study emphasizes ethnomathematics' role in meaningful learning by integrating mathematics with local culture. The Javanese calendar connects abstract mathematical theories to real-world applications through interactive education. The study suggests that ethnomathematics can boost student engagement, critical thinking, and cultural appreciation.
Keywords: *Javanese Culture; Etnomathematics; Learning Resources*

Abstrak
Sistem kalender Jawa kaya akan sejarah, filosofi, dan matematika. Studi etnomatematika ini meneliti konsep-konsep matematika kalender Jawa dan potensinya sebagai sumber pembelajaran untuk matematika dasar. Penelitian kualitatif ini mengumpulkan data melalui observasi langsung, wawancara, dan tinjauan pustaka. Studi ini menggunakan model analisis Miles dan Huberman untuk reduksi data, tampilan, dan penarikan kesimpulan. Sistem kalender Jawa—Tahun Saka, Wetonan, siklus bulan, siklus matahari, Pasaran, dan siklus Wuku—terkait erat dengan konsep matematika sekolah dasar. Ini termasuk perhitungan waktu, pengenalan pola, urutan siklis, pengukuran, bilangan bulat, pecahan, dan konversi. Studi ini menemukan bagaimana mengintegrasikan kalender Jawa ke dalam pendidikan matematika untuk meningkatkan pemahaman kontekstual siswa dan membuat pembelajaran lebih menarik serta relevan secara budaya. Studi ini menekankan peran etnomatematika dalam pembelajaran yang bermakna dengan mengintegrasikan matematika dengan budaya lokal. Kalender Jawa menghubungkan teori matematika abstrak dengan aplikasi dunia nyata melalui pendidikan interaktif. Studi tersebut menunjukkan bahwa etnomatematika dapat meningkatkan keterlibatan siswa, pemikiran kritis, dan apresiasi budaya.
Kata Kunci: Budaya Jawa; Etnomatematika; Sumber Belajar

Received	: 2025-02-06	Approved	: 2025-04-04
Reviesed	: 2025-03-20	Published	: 2025-04-30

Introduction

Mathematics and culture share a profound and complex relationship. Mathematics is not only a universal discipline but is also closely intertwined with values, beliefs, and cultural practices. The interconnection between mathematics and culture provides deep insights into the complexity of human intellectual heritage and how mathematical knowledge manifests in various aspects of human life. Most societies perceive mathematics merely as a subject that

studies arithmetic, whether at the school level or in higher education. However, mathematics should not be confined to theoretical learning alone; instead, it would be more beneficial if mathematics education were made more meaningful by applying it directly to everyday life (Kurniawati et al., 2021).

Education is an integral part of culture. Practically, the field of education is inseparable from cultural values. Empirical evidence indicates that current mathematics learning tends to be excessively dry, theoretical, lacking context, and superficial (Fatmahanik, 2019). Generally, teachers deliver mathematics instruction by explaining the material, providing example problems, demonstrating solutions, and concluding with exercises. Consequently, mathematics is often perceived as a difficult subject and an unenjoyable learning experience (Kurniawati et al., 2019). Furthermore, mathematics instruction in schools is excessively formal, making the mathematics that children encounter in everyday life vastly different from what they learn in school. This disconnection between formal mathematics instruction and students' lived experiences presents a significant challenge in elementary mathematics education, as it contributes to disengagement and difficulty in grasping abstract concepts. To prevent Indonesian culture from fading due to globalization, it is essential to integrate cultural elements into education and learning (Rawani & Fitria, 2022).

One approach that explores the relationship between mathematics and culture is ethnomathematics. Hammond (2000) explains that ethnomathematics studies how cultural values have shaped and been shaped by mathematics. Hammond (2000) uses this definition to examine how culture, gender, and race have influenced mathematical development despite its universal themes. Ethnomathematics serves as a bridge between mathematics and culture (Amirah & Budiarto, 2022). Borba (1990) defines ethnomathematics as an epistemological approach to mathematics that emphasizes cultural context. Based on his definition, mathematics is deeply influenced by different societies' cultures and beliefs. Borba suggests using ethnomathematics to connect mathematical concepts to students' cultural backgrounds to make math more meaningful. Through this mechanism, teachers applying ethnomathematics can promote dialogue and critical thinking, helping students see mathematics as a dynamic field shaped by diverse cultural experiences.

Indonesian society possesses a highly diverse cultural heritage. Unfortunately, cultural values are gradually being abandoned, and some individuals even feel ashamed of their cultural identity. As educators, one of the ways to preserve cultural heritage is by incorporating cultural elements into the learning process. In this regard, ethnomathematics offers an opportunity to address existing challenges in elementary mathematics education by contextualizing mathematical learning within students' cultural backgrounds.

The integration of mathematical content with Javanese culture, particularly in education, is meaningful in fostering students' ability to develop an appreciation for outstanding cultural heritage within a contemporary context. Mathematics skills cultivated through the integration of mathematics and culture are characterized by logical reasoning, rationality, and imagination, along with aesthetic appreciation. Through this approach, students are expected to recognize the applications and connections of mathematics not only across different disciplines but also in real-world contexts.

Ethnomathematics, as an approach that connects mathematics with cultural practices, plays a crucial role in shaping an applied curriculum that is both contextually relevant and pedagogically effective. By incorporating cultural elements into mathematics education, the curriculum becomes more meaningful and engaging, ensuring that mathematical practices align

with students' needs and interests, particularly for practical, aesthetic, and recreational purposes. Many cultures have developed counting practices tailored to their needs, often incorporating elements of art and design, such as symmetry, transformations, and proportions. Embedding these cultural aspects into the curriculum allows students to see mathematics as a living discipline, deeply rooted in their daily lives and traditions. Furthermore, by utilizing the cultural elements present in students' surroundings, teachers can create interactive and creative learning experiences, such as games and other enjoyable activities that involve mathematical concepts such as networks, strategies, and patterns.

Javanese society, for instance, has a cultural system known as Javanese culture, which serves as a valuable learning resource. One notable aspect of Javanese culture is its calendrical system, commonly referred to as the Javanese calendar. The Javanese calendar is widely used by the Javanese people to determine or predict auspicious and inauspicious days, personality traits, birth dates, marriage compatibility, death dates, the timing of harvests, travel plans, house construction, individual fortunes, and various other aspects of life. This Javanese calendrical system is deeply connected to mathematical concepts, such as cyclical patterns, modular arithmetic, and numerical sequences, making it an excellent resource for integrating ethnomathematics into the school curriculum. By engaging students with culturally relevant mathematical content, educators can help bridge the gap between abstract mathematical theories and real-world applications, enhancing both comprehension and interest.

Based on this discussion, given that mathematics is inseparable from culture, this study explores mathematical concepts within the Javanese calendrical system from an ethnomathematical perspective. Specifically, the study aims to investigate how the integration of the Javanese calendar into elementary mathematics education can help address existing challenges in teaching mathematics, enhance student engagement, and foster a deeper understanding of mathematical concepts within a meaningful cultural framework.

Research Methods

This descriptive qualitative research explored and described the mathematical values embedded in the traditional calculation system of the Javanese calendar. Qualitative research seeks to understand social phenomena and individual perspectives within a study (Syamsuddin & Damayanti, 2011). It was conducted to explore, identify, describe, and explain the values or meanings of a phenomenon, event, or social activity. In this study, the investigatd phenomenon consisted of activities related to the Javanese calendrical system. The research used ethnographic (socio-cultural) approach, focusing on the cultural aspects of a particular group of people.

Researchers observed traditional Javanese community members. Interviews enrich observations. Then, the researchers interviewed the Javanese elders about calendrical use with researchers. After that, the researchers interviewed the elementary teachers teaching Javanese calendar math. Then, the researchers analyzed the data with the analysis technique of Miles, Huberman, and Saldana (Retnawati, 2016). Research concluded with interpretation and reporting the implementation of Javanese calendars in everyday life and elementary math education.

This study took place in the province of Bengkulu. The selection of the research location was based on a thorough process of review and data analysis, grounded in the researcher's extensive observation and knowledge over a considerable period. The subjects included, first, the researcher as a member of the Javanese community; second, five Javanese people or village elders residing in Belitar Muka village, who were indigenous Javanese and possessed an

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understanding of calculations using the Javanese calendar; and third, sevent elementary school teachers or educators who were knowledgeable about mathematical concepts, along with relevant literature related to the Javanese calendrical system.

The researchers collected the data with observation, interview, and literature study. The data analysis technique applied the interactive scheme of Miles, Huberman, and Saldana (Retnawati, 2016). The scheme consists of data reduction, presentation, and verification. Figure 1 shows the data analysis.

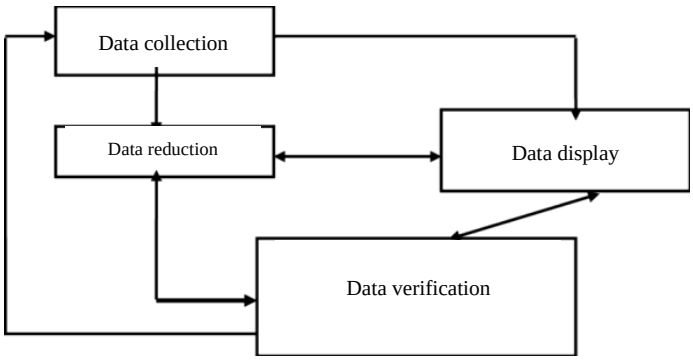

Figure 1. The Interactive Scheme of Miles, Huberman, and Saldana

Results and Discussion

Mathematics in the daily life of Javanese society is not limited to formulas and abstract concepts commonly studied in schools; rather, it is embedded in various aspects of their cultural and social life. Since ancient times, the Javanese people have developed numerous practical methods for managing resources, planning activities, and organizing time, all of which involve the application of mathematical principles. In this context, mathematics becomes an integral part of their culture and social practices, reflected in daily activities, calendrical systems, architecture, art, and even philosophical beliefs.

One of the most evident applications of mathematics in Javanese society is the Javanese calendrical system, consisting of the Saka Year and the Wuku cycle. This calendar integrates astronomical and mathematical concepts to determine time to regulate various societal activities, such as weddings, traditional ceremonies, and religious celebrations.

The Javanese calendar is a unique system that combines multiple cycles, including the lunar cycle (Hijri calendar), the solar cycle (Gregorian calendar), and various cultural elements that play a significant role in Javanese life. This system is highly influenced by lunar calculations, referring to the moon's orbit around the Earth. Mahfudi et al. (2024) explain each month in the Javanese calendar is determined based on the movement of the moon, lasting approximately 29.5 days (a synodic month). Since the lunar cycle does not perfectly align with the number of days in a Gregorian calendar month, the Javanese people employ intercalation calculations to adjust for these differences. Like other calendrical systems, the Javanese calendar also consists of 12 months. These months have names adapted from Arabic, modified to fit the Javanese phonetic system, namely: Sura, Sapar, Mulud, Bakdamulud, Jumadilawal, Jumadilakhir, Rejeb, Ruwah, Pasa, Sawal, Dulkangidah, and Besar (Ulva & Istianah, 2024). However, to maintain alignment with the Earth's orbit around the sun, the Javanese calendar incorporates an additional intercalary month after specific cycles.

The Javanese calendrical system is a cultural heritage rich in historical and philosophical values. From a mathematical perspective, this system also demonstrates mathematical concepts applied in the daily lives of the Javanese people through time calculation mechanisms used for social, religious, and cultural purposes. In the context of ethnomathematics, the Javanese calendar serves as an example of how mathematics is integrated into local culture, encompassing aspects such as cyclicity, time division, and numerical management.

Another key concept in the Javanese calendrical system is **weton**. *Wetonan* is an essential element of the Javanese calendar that is directly related to determining an individual's birth date, which is then associated with fate, destiny, and fortune based on Javanese astrology. The *wetonan* cycle consists of five days, named Legi, Pahing, Pon, Wage, and Kliwon. Each day within this cycle carries specific astrological and symbolic influences that are believed to affect an individual's life. Based on an interview conducted with Mr. SW, the findings obtained are considered valid and are presented in Table 1.

Table 1. Wetonan: the Five-Day Cycle

Days		Remarks
First day	Legi	Believed to have excellent fortune or specific positive aura
Second day	Pahing	Believed to have certain characteristics related to excellent fortune or specific energy
Third day	Pon	Believed to have specific meaning based on Javanese astrology
Fourth day	Wage	Commonly associated to something balance or neutral energy
Fifth day	Kliwon	Believed to have strength within astrological effects and influence toward lucky and bad luck

The Javanese calendrical system is a unique and intricate timekeeping framework that integrates mathematical principles with cultural traditions. It encompasses the *pasaran* cycle, *wuku* cycle, and lunar-solar calendar, all of which demonstrate mathematical applications such as modular arithmetic, number rounding, fractions, multiplication, and division. These elements are deeply embedded in Javanese society, influencing daily life, timekeeping, and important decision-making processes.

Table 1 shows the *pasaran* cycle, a five-day repeating system where each day—Legi, Pahing, Pon, Wage, and Kliwon—is believed to carry specific characteristics and astrological influences. Legi is thought to bring excellent fortune, while Pahing is associated with prosperity and success. Pon holds astrological significance in personal and communal events, Wage is linked to balance, and Kliwon is considered a powerful day that can bring both good and bad luck. These beliefs influence various social decisions, including selecting auspicious days (*hari baik*) for ceremonies, weddings, and business inaugurations, while also avoiding inauspicious days (*hari buruk*).

The *wetonan* system, which combines the *pasaran* cycle with the seven-day Gregorian week, plays a crucial role in Javanese astrology and cultural practices. By analyzing a person's *weton* (birthdate), individuals determine compatibility in relationships, career paths, and even the success of important endeavors. Risdiyanti et al. (2017) explain this fusion of mathematical cycles with cultural significance highlights how ethnomathematics is applied in Javanese traditions.

From an ethnomathematical perspective, the Javanese calendrical system provides a compelling example of how societies employ mathematical concepts within a cultural framework. The calendar reflects the use of cyclical patterns, time divisions, and modular arithmetic, which serve as fundamental mathematical applications in elementary education.

One significant mathematical concept in the Javanese calendar is the calculation of time using whole numbers and fractions. The system rounds each lunar month to 30 days, despite the actual lunar cycle lasting approximately 29.5 days. This provides students with an opportunity to learn about number rounding and the differences between the Gregorian and Javanese calendars. Furthermore, Hidayati et al. (2022) assert this matter can encourage students explore fractional representations by analyzing the 0.5-day remainder in the lunar cycle, introducing concepts of fractions and decimal approximations.

Multiplication and division are also integral to the Javanese calendrical system. The *wuku* cycle consists of 30 days, while the *pasaran* cycle repeats every five days. These cycles allow students to practice division by calculating how many *pasaran* cycles occur within one *wuku* (30 ÷ 5 = 6). Exponentiation concepts can also be introduced through extended calculations involving multiple cycles, helping students understand periodicity and exponential growth within repeating patterns.

The Javanese calendar serves as a practical tool for teaching elementary mathematics, particularly in time calculations, cyclical patterns, and conversions. The first implementation includes teaching students to calculate the number of days in a Javanese month (30 days) or to compute lunar and annual cycles using division and multiplication. For example, students can analyze how the Javanese calendar rounds the 29.5-day lunar cycle to 30 days, demonstrating the application of mathematical operations. Additionally, they can explore fractions by examining time divisions within lunar cycles, such as calculating the remaining 0.5 days in a synodic month.

The second implementation involves understanding multiplication and division through the *wuku* and *pasaran* cycles. Since a *wuku* lasts 30 days and the *pasaran* repeats every five days, students can divide a larger cycle into smaller components. For instance, they can calculate the number of *pasaran* cycles within a *wuku*, and use exponentiation to analyze long-term calendar cycles. These activities help students recognize cyclical repetition, a fundamental principle in both mathematics and astronomy.

Pattern recognition is another key mathematical concept that can be explored using the Javanese calendar. The five-day *pasaran* cycle allows students to predict future occurrences based on established sequences. Understanding these cycles reinforces logical sequencing, periodicity, and modular arithmetic, which are fundamental topics in elementary mathematics education. For example, students can calculate when a specific *weton* will repeat or determine how often a particular day falls on a given date.

Another essential mathematical aspect of the Javanese calendar is the conversion between different timekeeping systems. The Saka Year, which began in 78 AD, follows a lunar-solar system, while the Gregorian calendar is purely solar. Students can engage in applied arithmetic by learning to convert between these systems using the formula: Gregorian Year = Saka Year + 78

This concept not only helps students develop arithmetic skills but also fosters an understanding of cultural timekeeping variations. By comparing different calendar systems, students gain insights into how societies structure time based on astronomical observations and historical traditions.

Mathematics in Javanese society is not confined to abstract theories but is intricately woven into daily life, cultural traditions, and decision-making processes. The calendrical system, along with its applications in astrology, agriculture, and traditional ceremonies, demonstrates how mathematical principles serve practical functions. The study of ethnomathematics within the Javanese calendar showcases how mathematical reasoning is naturally embedded in cultural heritage and remains relevant in contemporary education.

By integrating the Javanese calendrical system into mathematics education, students can develop a deeper appreciation for the real-world applications of mathematics beyond abstract computations. Wulandari et al. (2024) asserts culturally relevant approach fosters critical thinking and contextual learning, demonstrating how mathematical concepts are used to organize time, predict events, and sustain traditions in Javanese society.

Conclusion

The Javanese calendrical system exemplifies the deep interconnection between mathematics and cultural traditions, demonstrating how mathematical principles such as modular arithmetic, fractions, rounding, and cyclical patterns are embedded in daily life. Through the *pasaran* and *wuku* cycles, timekeeping is not only a practical necessity but also a cultural tool for determining auspicious days, organizing ceremonies, and making important life decisions. From an ethnomathematical perspective, the Javanese calendar serves as an educational resource that enhances students' understanding of mathematical concepts in a culturally relevant context. By incorporating this system into elementary mathematics education, students can explore practical applications of division, multiplication, exponentiation, and pattern recognition while also gaining an appreciation for different timekeeping traditions.

Furthermore, the Javanese calendar fosters a broader understanding of time conversion between calendrical systems, illustrating how societies structure their calendars based on historical and astronomical observations. The integration of these mathematical concepts into cultural practices reinforces the idea that mathematics is not merely an abstract discipline but a fundamental aspect of human civilization, shaping traditions, societal organization, and daily decision-making. Ultimately, the Javanese calendrical system highlights the enduring significance of mathematical reasoning in cultural heritage. Its continued use in modern Javanese society underscores the practical applications of mathematics beyond the classroom, demonstrating that mathematical knowledge is not only universal but also deeply rooted in local traditions and historical contexts.

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