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Bridging culture and math: the javanese calendar as an educational tool

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Abstract

The integration of cultural elements in mathematics education has gained increasing attention as a means to enhance student engagement and contextualize learning. The Javanese calendar, deeply embedded in Javanese culture, contains mathematical structures that offer potential applications in mathematics education. However, its utilization as a pedagogical tool remains underexplored, particularly in formal school curricula. This study investigates the mathematical principles underlying the Javanese calendar and explores its potential for developing a culturally integrated mathematics curriculum. Employing a qualitative research approach, we conducted a document analysis of primary sources related to the Javanese calendar alongside school mathematics literature. The findings reveal that the Javanese calendar encompasses fundamental mathematical concepts, including number recognition, addition, multiples of numbers, and the Lowest Common Multiple (LCM). Notably, the synchronization of the *Pancawara* (5-day) and *Saptawara* (7-day) cycles exemplifies the application of LCM in determining recurring time intervals. Moreover, implicit mathematical concepts such as number sets, data presentation, relations, and functions can be derived from the Javanese calendar. This study highlights the potential for incorporating the Javanese calendar into the mathematics curriculum to foster culturally relevant learning experiences, enhance student comprehension, and serve as supplementary material to enrich existing instructional approaches.

Keywords: Arithmetic Sequence, Ethnomathematics, Javanese Calendar, Lowest Common Multiple, Set and Number

Introduction

The incorporation of cultural elements into educational curricula has received growing scholarly attention due to its potential to enhance student learning by fostering deeper engagement and contextual relevance (Caingcoy, 2023). Integrating cultural themes within instructional practices not only facilitates the acquisition of new knowledge but also enriches students' learning experiences by making them more meaningful and relatable (Byrd, 2016). Among the diverse cultural contexts available for integration into mathematics education, the Javanese calendar represents a valuable source of ethnomathematical knowledge with significant pedagogical potential (D'Ambrosio, 2006).

Previous research has investigated the role of calendars in mathematics education across various educational levels, ranging from foundational learning activities, such as number recognition and time concept development, to more advanced applications in ethnomathematical analyses of indigenous calendars. The pedagogical utilization of calendars is evident in early childhood education, where they are employed to facilitate sequencing, number recognition, graphical representation, time measurement, counting, pattern formation, place value understanding, and the organization of days and months (Ethridge & King, 2005). Furthermore, studies have examined the integration of Maya calendars in classroom instruction (Taylor et al., 2015), novice primary school teachers' experiences with curriculum pacing calendars in mathematics and science education (Bauml, 2015), and ethnomathematical investigations of traditional calendar systems, such as the *Mangse* system in the Sasak calendar (Hastuti et al., 2022) and the Baduy tribe's calendar system (Arisetyawan & Supriadi, 2020). Additional research has explored European pagan calendars (Bjarnadottir, 2010), Javanese and Balinese adaptations of Indic calendars (Proudfoot, 2007), and models of solar and lunar motion in the Chinese Chongxiu-Daming calendar (Choi et al., 2018). Collectively, these studies underscore the importance of contextualizing calendar systems in mathematics education, as they provide students with culturally relevant and meaningful learning experiences that bridge abstract mathematical concepts with real-world applications.

In the Javanese cultural context, the calendar is deeply embedded in daily life, making it a relevant and familiar tool for students in Java, Indonesia. Integrating the Javanese calendar into mathematics instruction provides a culturally contextualized framework for learning mathematical concepts, enabling students to recognize the practical applications of mathematics in real-world settings. This approach enhances both comprehension and retention by linking abstract mathematical principles to tangible experiences. The Javanese calendar is a complex system that synthesizes elements from the Gregorian, Islamic, and Hindu calendars (Karjanto & Beauducel, 2021). Its structure is rooted in astronomical cycles, numerology, and cultural traditions, encapsulating various mathematical principles (Utami et al., 2022). The analysis of its cyclical patterns and congruence relations fosters students' logical reasoning, critical thinking, and problem-solving skills while simultaneously reinforcing their understanding of mathematical concepts. Furthermore, the Javanese calendar serves as a multidisciplinary educational resource, bridging mathematics with history, culture, and astronomy. This interdisciplinary approach enriches students' learning experiences by fostering connections across diverse academic domains.

Several studies have examined the educational applications of the Javanese calendar, highlighting its role in agricultural timekeeping through the *Pranatamangsa* system (Prahmana et al., 2021), its significance in birth and death ceremonies (Prahmana et al., 2021; Utami et al., 2020), and its use in marriage customs (Utami et al., 2019). Additionally, the calendar has been investigated for its mathematical applications in number theory (Nuraeni & Azizah, 2017) and as a contextual tool for teaching number patterns and least common multiples (Zulkardi & Setiawan, 2020). Moreover, it has been employed to determine Islamic holy days and traditional ceremonies in Cirebon *Kasepuhan* Palace (Syahrin et al., 2016). Collectively, these studies underscore the cultural and mathematical significance of the Javanese calendar, demonstrating its potential to bridge ethnomathematics with formal mathematics education.

Despite the growing body of research on the cultural and mathematical dimensions of the Javanese calendar, its systematic integration into the mathematics curriculum remains insufficiently explored. Existing studies have yet to comprehensively investigate its potential as a structured pedagogical tool for teaching specific mathematical concepts. To address this gap, the present study seeks to examine the effective incorporation of the Javanese calendar into mathematics instruction, identifying opportunities for designing meaningful learning activities that enhance student engagement and conceptual understanding.

Methods

This qualitative study investigates the cultural significance of the Javanese calendar from a mathematical perspective (D'Ambrosio, 1985; 2015; D'Ambrosio & Rosa, 2017; Geertz, 1973). The research was conducted through an extensive document review, focusing on primary sources such as the Javanese Book *Qomarrulsyamsi Adammakna* and Javanese Book *Betaljemur Adammakna*, along with other historical documents that provide insights into the development and application of the Javanese calendar. The selection of these documents was based on their historical significance, authenticity, and relevance to understanding the mathematical structures embedded within the Javanese calendar.

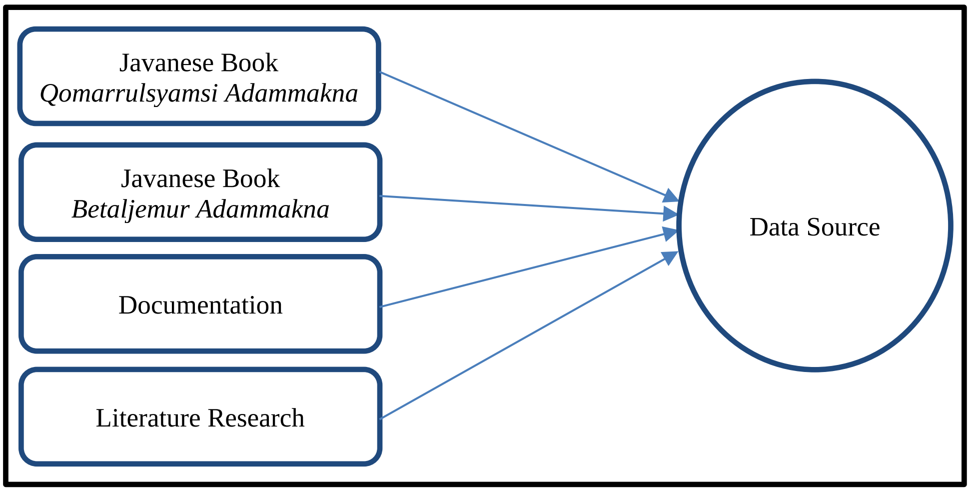

Figure 1. Data Triangulation

Furthermore, this study incorporated documentation methods and an in-depth literature review, encompassing scholarly sources such as journal articles, conference proceedings, online resources, research papers, dissertations, and theses. The collected data were analyzed using content analysis to interpret cultural elements from a mathematical viewpoint, thereby constructing a mathematical knowledge system derived from the cultural environment (D'Ambrosio, 1985; 2015). To ensure the reliability and validity of the findings, data triangulation was employed by corroborating information from multiple sources (see Figure 1).

Results and Discussion

The Javanese calendar is a lunisolar system that integrates elements from the Saka Hindu, Islamic lunar, and Western Gregorian calendars (Karjanto & Beauducel, 2021). This calendar follows a seven-day cycle, analogous to the Gregorian calendar, comprising Sunday, Monday, Tuesday, Wednesday, Thursday, Friday, and Saturday. This cycle, referred to as the *Saptawara* cycle (where *sapta* means seven), serves as a fundamental timekeeping unit within the Javanese system. Additionally, the Javanese calendar incorporates a distinct five-day cycle, which has no counterpart in the Gregorian calendar. This cycle, known as the *Pancawara* cycle (*panca* meaning five), consists of the days *Pon, Wage, Kliwon, Legi*, and *Pahing*. The integration of these two cycles results in a 35-day *Wetonan* cycle, which represents the interaction between the *Saptawara* and *Pancawara* cycles.

Table 1. Numerical Symbol of Days

Days in the Georgian calendar (*Saptawara*)	***Neptu* (Javanese) or Numerical Symbol (Math)**
Sunday	5
Monday	4
Tuesday	3
Wednesday	7
Thursday	8
Friday	6
Saturday	9

Beyond its function as a chronological system, the Javanese calendar such as *pasaran* embeds mathematical concepts through its use of numerical values and symbolic representations (see Table 2). Two key mathematical elements within this system are *neptu* and *weton*. The term *neptu* refers to the numerical value assigned to each day (see Table 1), while *weton* represents the sum of the corresponding *neptu* values (see Table 3).

Table 2. Numerical Symbol of *Pasaran*

Days in the Lunar Cycles (*Pancawara*)	***Neptu* (Javanese) or Numerical Symbol (Math)**
Pon	7
Wage	4
Kliwon	8
Legi	5
Pahing	9

Conceptually, *neptu* can be interpreted as a mathematical number symbol, whereas *weton* denotes the aggregate of these values. The integration of *neptu* and *weton* within cultural traditions provides an opportunity for students to explore fundamental mathematical concepts such as number properties, arithmetic operations, and numerical sequences. By incorporating these culturally embedded mathematical principles into the learning process, students can develop a deeper appreciation for the mathematical structures inherent in traditional knowledge systems while enhancing their engagement with mathematical reasoning.

Table 3. Numerical Symbol of *Weton*

Days	**Numerical Symbol of *Neptu* Summation**	**Numerical Symbol of *Weton* (*Neptu* Summation Results)**
Sunday *Pon*	5 + 7	12
Sunday *Wage*	5 + 4	9
Sunday *Kliwon*	5 + 8	13
Sunday *Legi*	5 + 5	10
Sunday *Pahing*	5 + 9	14
Monday *Pon*	4 + 7	11
Monday *Wage*	4 + 4	8
Monday *Kliwon*	4 + 8	12
Monday *Legi*	4 + 5	9
Monday *Pahing*	4 + 9	13
Tuesday *Pon*	3 + 7	10
Tuesday *Wage*	3 + 4	7
Tuesday *Kliwon*	3 + 8	11
Tuesday *Legi*	3 + 5	8
Tuesday *Pahing*	3 + 9	12
Wednesday *Pon*	7 + 7	14
Wednesday *Wage*	7 + 4	11
Wednesday *Kliwon*	7 + 8	15
Wednesday *Legi*	7 + 5	12
Wednesday *Pahing*	7 + 9	16
Thursday *Pon*	8 + 7	16
Thursday *Wage*	8 + 4	12

Thursday *Kliwon*	8 + 8	16
Thursday *Legi*	8 + 5	13
Thursday *Pahing*	8 + 9	17
Friday *Pon*	6 + 7	13
Friday *Wage*	6 + 4	10
Friday *Kliwon*	6 + 8	14
Friday *Legi*	6 + 5	11
Friday *Pahing*	6 + 9	15
Saturday *Pon*	9 + 7	16
Saturday *Wage*	9 + 4	13
Saturday *Kliwon*	9 + 8	17
Saturday *Legi*	9 + 5	14
Saturday *Pahing*	9 + 9	18

The Javanese calendar incorporates mathematical values that can be effectively utilized in mathematics education. These values exist in both explicit and implicit forms, with the former being directly observable and the latter requiring deeper exploration. Both types of mathematical values present opportunities for educators to design engaging, contextual, and innovative mathematics lessons that align with students' cultural backgrounds.

The mathematical concepts embedded within the Javanese calendar include number recognition, addition, numerical sequences, multiples of numbers, least common multiple (LCM), greatest common factor (GCF), number sets, data representation, relations, and functions. By integrating these elements into the curriculum, educators can create learning experiences that enhance students' conceptual understanding while fostering an appreciation for the mathematical structures inherent in traditional knowledge systems.

Recognizing Numbers

The ability to recognize numbers in early education is fundamental to developing essential mathematical skills. Various pedagogical approaches and instructional tools have been explored to enhance young children's number recognition and comprehension. However, many early learners encounter difficulties in identifying numerical symbols and associating them with corresponding quantities. Therefore, implementing creative and engaging instructional strategies is essential to address these challenges effectively (Syarifuddin et al., 2022).

One potential approach to fostering number recognition is the integration of the Javanese calendar into mathematics instruction. Elementary school students can be introduced to numerical symbols through the distinct representations found within the Javanese calendrical system. The use of visual representations has been shown to support students in memorizing and internalizing numerical concepts, thereby strengthening their understanding of numeral structures and relationships (Newcombe, 2013).

Addition of Numbers

The addition of natural numbers is a fundamental concept taught di elementary school. Difficulties in learning addition can stem from reduced cognitive efficiency and the need for a strong conceptual understanding of numbers (Budínová & Janík, 2021). Addition is typically taught in context, so helping students apply it to real life can help them to understand (Stephan & Akyuz, 2012). For example, students may respond differently to addition problems presented in different formats or contexts, such as physical representations (Shaki et al., 2015; Stephan & Akyuz, 2012).

Javanese calendars can be utilized as a physical representation for learning number addition for lower-grade elementary school children. Activities can be carried out, for example, by using tools and materials: Javanese calendars and pens. Students are taught to calculate the sum of 7 and 5.

$$7 + 5 = \ldots$$

Students are asked to circle the number 7, then students are asked to circle many five numbers, and then it will arrive at the number 12. The limitation is that the numbers presented are only up to 30 or 31. However, this is still possible in grade 1 as a preliminary in learning maths.

Instead of limiting the addition to small numbers, students could be tasked with adding numbers from different cycles, demonstrating how these operations work within the context of both the *Saptawara* and *Pancawara* cycles. For example, students can determine the sum of a given *Weton* (a combination of days from both cycles), Wednesday *Legi*, students can calculate the total numerical value by adding *neptu* of Wednesday and *neptu* of *Legi*. Then, they can be given a more complex task, such as finding the *Weton* for a day 25 days later. Using their knowledge of modular arithmetic on both cycles (mod 7 and mod 5), they can find out what the corresponding day and *Weton* of that future date will be, which embeds the idea of cyclical addition in a real-world cultural context.

Multiples of Numbers

Many students encounter difficulties in understanding numerical magnitude and relationships, which can impede their ability to comprehend the concept of multiples. Addressing these challenges through targeted instructional strategies and interventions is crucial for fostering mathematical proficiency (Gabriel et al., 2023). Incorporating real-world contexts into mathematics instruction allows students to recognize the practical applications of multiples and other mathematical concepts, thereby enhancing their conceptual understanding while increasing engagement and motivation (Tuong et al., 2023).

In mathematics, multiples of a number are obtained by multiplying a given natural number by a sequence of whole numbers. A culturally relevant example of this concept is the 35-day *selapanan* baby celebration in Javanese tradition, which follows a calendrical cycle based on multiples of 7 and 5. In the context of modern mathematics, the multiples of 7 include 7, 14, 21, 28, and 35, while the multiples of 5 include 5, 10, 15, 20, 25, 30, and 35. Integrating such culturally embedded numerical patterns into mathematics education provides students with a meaningful and contextualized understanding of numerical relationships.

Least Common Multiple and Greatest Common Factor

Number multiples are closely related to number factors, as factors of a given number are the values that divide it completely without leaving a remainder. Two fundamental concepts associated with number multiples and factors are the GCF and the LCM. The GCF of two numbers refers to the largest factor they share, while the LCM represents the smallest positive integer that is evenly divisible by both numbers. In other words, the LCM is the smallest common multiple of two integers (Ozturk, 2021). Understanding GCF and LCM is essential for proving mathematical theorems and solving various problems in number theory. Additionally, the context in which problems are presented significantly influences students' ability to correctly apply GCF and LCM concepts (Martinez & Valverde, 2022).

The Javanese calendar provides a valuable contextual framework for introducing GCF and LCM, as it is structured around multiple cyclic patterns. By leveraging the cyclical nature of the Javanese calendar, educators can design meaningful instructional activities that enhance students' understanding of these mathematical concepts. The interplay between the *Pancawara* (five-day market cycle) and *Saptawara* (seven-day week cycle) offers a natural example of how different cycles interact, overlap, and reset after a specific period. Through this approach, students can develop a deeper comprehension of number relationships and periodicity in mathematics.

A structured instructional approach can be implemented as follows: (1) The teacher introduces the *Pancawara* and *Saptawara* cycles using the Javanese calendar as an instructional tool; (2) students identify specific recurring day combinations, such as Sunday Wage; (3) students search for the next occurrence of the same day combination within the calendar; (4) students count the number of days between two occurrences of the same combination; and (5) students determine a mathematical method to calculate this without direct reference to the calendar.

An illustrative example involves determining the LCM using the *Pancawara* and *Saptawara* cycles in the Javanese calendar. Suppose we want to identify when Monday Legi will next coincide.

- The Javanese Pasaran cycle repeats every 5 days: *Legi* → *Pahing* → *Pon* → *Wage* → *Kliwon* → *Legi*
- The Gregorian week repeats every 7 days: Monday → Tuesday → Wednesday→ Thursday → Friday→ Saturday →Sunday → Monday

Since these two cycles operate independently, the LCM of 5 and 7 determines when they realign. The LCM (5,7) = 35, indicating that Monday Legi will recur every 35 days. This example provides a tangible application of the LCM concept in real-world cyclic patterns, making it more accessible for students.

To further reinforce learning, enrichment activities such as problem-solving exercises and interactive games can be integrated into classroom instruction. For instance, students can engage in crossword puzzles designed around the Javanese calendar, promoting the recognition of cycles and patterns while strengthening their mathematical reasoning and calculation skills.

A sample crossword puzzle incorporating the Javanese calendar context is provided in Figure 2.

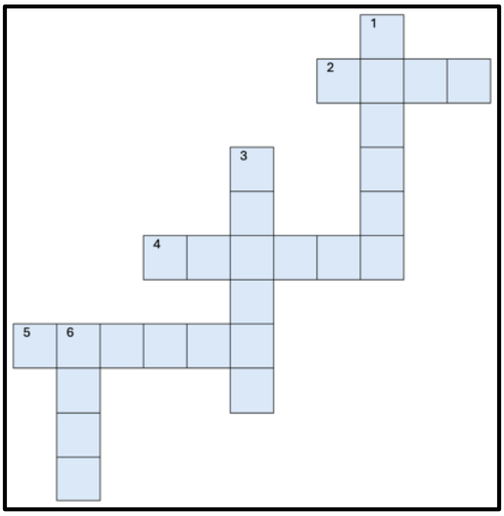

Figure 2. Crossword Puzzle with Javanese Calendar Context

Fill in the crossword puzzle above with the following questions.

Flat

2. Roni saves money at the bank every 6 days. Bayu saves money at the bank every 16 days. Andre saves money at the bank every 24 days. Iwan saves money at the bank every 48 days. If they save money at the Bank together on 2 January 2023, then what date would they save money at the Bank together again?
4. Irma swims every 6 days, and Ratna swims every 5 days. If they swim together on 8 January 2023, on what date will they swim together again??
5. Kania does maths every 7 days, and Dira does it every 4 days. If they studied together on 1 August 2023, what date will they study together again?

Decline

1. Roni saves his money in the class treasury every 6 days. Bayu saves his money in the class treasury every 16 days. Andre saves his money in the class treasury every 24 days, and Iwan saves his money in the class treasury every 48 days. If they saved their money in the class treasury together on 2 January 2023, what date did they save it?
3. Ali takes science every 6 days, and Dina takes science every 5 days. If they take science lessons together on 8 January 2023, what date will they take them again??
6. Alvin visits the library every 3 days, and Zury visits the library every 4 days. If they visited the library on 20 May, on which date did they visit the library together again?

Sequence of Numbers

Sequences represent an important facet of analysis, with the ability to articulate ordered lists of rational numbers (Baronti et al., 2016). These enumerations are inherently flexible, permitting the inclusion of an infinite number of elements, as is often assumed in such contexts. Arithmetic sequences are utilized in various mathematical and real-world applications (Jupri et al., 2022).

The Javanese calendar also has the mathematical value of an arithmetic sequence with a difference of 7—for example, the arithmetic sequence 1,8,15,22,29.

$$U1 = 1$$
$$U2 = 8$$
$$U3 = 15$$
$$U4 = 22$$
$$U5 = 29$$

Then this is the arithmetic sequence with $a = 1, b = 7$, and Un with $n = 5$, which is 29.

$$Un = a + (n-1)b$$
$$U2 = 1 + (2-1)7$$
$$= 1 + 7$$
$$= 8$$
$$U3 = 1 + (3-1)7$$
$$= 1 + 14$$
$$= 15$$
$$U4 = 1 + (4-1)7$$
$$= 1 + 21$$
$$= 22$$
$$U5 = 1 + (5-1)7$$
$$= 1 + 28$$
$$= 29$$

The other arithmetic sequence is 2,9,16,23,30; 3,10,17,24,31; 4,11,18,25; 5,12,19,26; 6,13,20,27; 7,14,21,28, etc.

The Set of Numbers

Sets can be defined as collections of objects of the same kind, among the fundamental notions in many mathematical subjects. Operations such as union, intersection, and difference are fundamental operations on sets of numbers (Bagdasar, 2013b).The Javanese calendar can be utilized in learning for numbers set. We can utilize the Javanese calendar in set material in mathematics because the characteristics of days and dates in the Javanese calendar can be members of certain sets. Hence, it allows the Javanese calendar to be utilized as the material for teaching the set. For example,

$$Set\ of\ A = \{Days\ of\ the\ week\}$$
$$= \{Monday, Tuesday, Wednesday, Thursday, Friday, Saturday, Sunday\}$$
$$Set\ of\ B = \{Days\ of\ Pasaran\}$$
$$= \{Pon, Wage, Kliwon, Legi, Pahing\}$$

We can also design the others set as context for learning mathematics.

Data Presentation

The Javanese calendar provides a valuable context for teaching data presentation. By utilizing data from the Javanese calendar, students can learn to organize and represent information in various forms, including tables (see Table 1, Table 2), arrow diagrams (see Figure 3), and bar charts. These data visualization techniques enable students to analyze information more effectively by identifying patterns, making comparisons, and observing trends.

Presenting data through visual methods, such as bar charts and arrow diagrams, enhances students' ability to interpret and understand numerical relationships. By engaging with multiple representation formats, students develop critical data analysis skills, allowing them to recognize significant differences and trends within the data. Integrating the Javanese calendar into these lessons not only contextualizes mathematical concepts but also fosters a deeper appreciation for the cultural significance of cyclical patterns in traditional timekeeping.

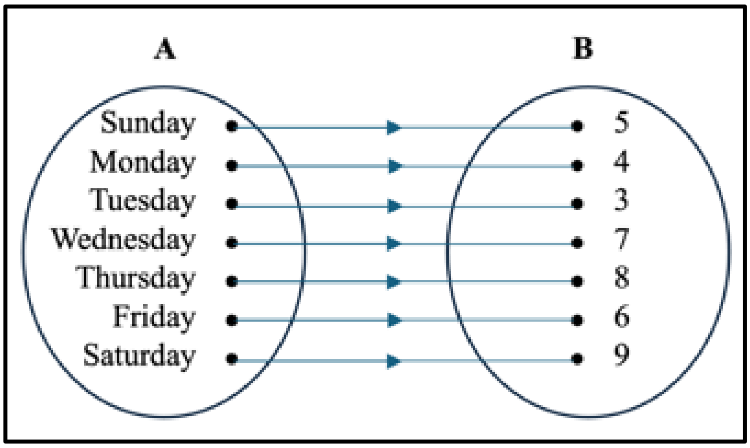

Figure 3. Arrow Diagrams of *Neptu* Days

Relations and Functions

In mathematics a binary relation between two sets A and B is a collection of ordered pairs (a,b) belonging to the cartesian product $A \times B$ (Bagdasar, 2013a). Data in the form of sets of Javanese Calendar can be presented as arrow diagrams (see Figure 3) to explain the material of relations and functions.

Conclusion

This study highlights the potential of the Javanese calendar as an effective bridge between cultural heritage and school mathematics, demonstrating its relevance as a contextual learning tool. The integration of the Javanese calendar in mathematics instruction provides students with opportunities to explore fundamental mathematical concepts such as number recognition, addition, numerical sequences, multiples of numbers, least common multiple (LCM) and greatest common factor (GCF), number sets, data presentation, relations, and functions. By embedding these concepts within a culturally meaningful framework, students can develop a deeper understanding of mathematical principles while fostering an appreciation for their cultural heritage. Additionally, this approach allows educators to design creative and engaging learning experiences that enhance student comprehension and retention. While the findings suggest that incorporating the Javanese calendar into mathematics education has the potential to make learning more relevant and accessible, this study has certain limitations. The research primarily focuses on the theoretical and pedagogical potential of the Javanese calendar without extensive empirical validation across different classroom settings. Furthermore, the findings are context-specific and may not be generalizable beyond regions where the Javanese calendar is culturally significant. Factors such as teacher preparedness, curriculum integration, and variations in student background knowledge were not extensively examined, which could influence the successful implementation of this approach. Addressing these limitations will be crucial in gaining a more comprehensive understanding of the impact of the Javanese calendar in mathematics education.

Future research should focus on the practical application of the Javanese calendar in diverse educational settings, particularly its impact on student engagement, motivation, and mathematical achievement. Empirical studies using experimental and quasi-experimental designs could provide valuable insights into its effectiveness compared to traditional teaching methods. Additionally, longitudinal studies could examine the long-term benefits of integrating cultural elements into mathematics instruction, particularly in developing students' problem-solving skills and mathematical reasoning. Expanding research to include different age groups, cultural backgrounds, and curriculum structures would further enhance the applicability of this approach across various educational contexts. Moreover, investigating teacher perceptions, professional development needs, and instructional strategies for implementing the Javanese calendar in formal mathematics curricula would provide practical guidance for educators. By addressing these areas, future research can contribute to the advancement of culturally responsive mathematics education, ensuring that students not only develop strong mathematical competencies but also a deeper appreciation for the cultural dimensions of learning.

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Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript. In addition, the authors have covered ethical issues, including plagiarism, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies completely.

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