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Cultural insights into arithmetic sequences: a study of chinese zodiac and its elements

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Abstract

Ethnomathematics examines the intersection of mathematics and cultural practices, revealing how mathematical principles are embedded within societal traditions. Despite extensive research in ethnomathematics, limited studies have explored its application in understanding the Chinese zodiac system and its mathematical foundations. This study addresses this gap by investigating the mathematical structures underlying the determination of the Chinese zodiac and its elements, offering a novel perspective on how arithmetic sequences and modular arithmetic are utilized within this cultural tradition. The study aims to formulate these traditional calculations into a mathematical framework, thereby bridging cultural heritage and mathematical learning. Employing a qualitative research design with an ethnographic approach, data collection was conducted through field observations, in-depth interviews, and thematic analysis to ensure validity, reliability, and representativeness. The findings reveal that the determination of the Chinese zodiac and its elements involves fundamental mathematical operations such as multiplication, addition, and modular arithmetic. This study not only demonstrates the inherent mathematical reasoning within cultural traditions but also contributes to the broader discourse on mathematics education by integrating cultural contexts into learning. Finally, the results have significant implications for mathematics education, offering an alternative pedagogical approach that enhances students' engagement and comprehension by contextualizing mathematical concepts within real-life cultural practices.

Keywords: Arithmetic Sequences, Chinese Calendar, Chinese Zodiac, Element, Ethnomathematics

Introduction

Numerous research highlights that the Chinese zodiac is deeply ingrained in traditional Chinese culture, serving as a reflection of societal transformations, ecological perspectives, and individuals' aspirations for prosperity and well-being. The twelve animal symbols associated with the zodiac embody diverse connotations that have evolved since the Qin and Han dynasties, illustrating the intricate relationship between humans and nature (Xue-jing, 2012; Yanw, 2013; Haobin & Jiguang, 2022). However, while these cultural aspects are significant, they fall outside the primary scope of this study. Instead, this research focuses on examining the mathematical structures embedded within the Chinese zodiac and their applicability in educational contexts, particularly through the lens of arithmetic sequences.

The Chinese calendar, which is closely interwoven with the zodiac system, incorporates fundamental mathematical and astronomical principles. These principles involve the application of arithmetic operations and modular arithmetic to determine zodiac signs, and their corresponding elements based on cyclical year patterns. For instance, an individual’s zodiac sign is assigned by correlating their birth year with one of twelve recurring animal symbols, adhering to a fixed sequential pattern. The arithmetic sequences inherent in this system provide a systematic framework for associating specific years with zodiac signs (Ho et al., 1991; Xiaochun, 2006). This study specifically investigates how these mathematical principles, particularly arithmetic sequences, underpin the determination of zodiac signs and elements, thereby demonstrating their potential integration into mathematics education. By establishing a connection between abstract mathematical concepts and cultural traditions, this research aims to enhance the relevance and engagement of mathematics learning.

Ethnomathematics, which examines the interplay between mathematics and cultural practices, provides a foundational framework for this study. It emphasizes the cultural contextualization of mathematical concepts and methodologies, illustrating how arithmetic structures embedded in the Chinese calendar can serve as pedagogical tools for mathematics education. For example, the application of modular arithmetic to determine zodiac signs based on cyclic birth year rotations not only streamline computational processes but also offers a culturally meaningful approach to teaching arithmetic sequences. This perspective aligns with D’Ambrosio’s (1985) assertion that ethnomathematics bridges diverse cognitive frameworks and cultural traditions with mathematics education, fostering a more profound and contextualized understanding of mathematical concepts.

Although previous research has broadly explored ethnomathematics, its specific application to the Chinese zodiac in relation to arithmetic sequences remains underdeveloped. This study seeks to address this research gap by systematically analyzing the arithmetic sequence patterns underlying the determination of zodiac signs, formulating these patterns into mathematical expressions, and investigating their potential applications in educational contexts. By doing so, the study underscores the innovative potential of integrating cultural and mathematical perspectives to enrich learning experiences and enhance students' engagement with mathematical concepts.

The objectives of this research are twofold: first, to identify and articulate the arithmetic sequence patterns inherent in the Chinese zodiac system, and second, to evaluate how these patterns can serve as an entry point for teaching arithmetic sequences in mathematics education. Employing qualitative research methods, including ethnographic analysis and interviews, this study offers a comprehensive examination of the mathematical foundations of the Chinese zodiac system and explores their transformation into meaningful instructional resources.

This research is distinctive in its interdisciplinary approach, integrating arithmetic sequences, cultural traditions, and their application in mathematics education. By linking the abstract mathematical structures underlying the Chinese zodiac to practical educational strategies, this study contributes to both the fields of ethnomathematics and mathematics education, offering novel insights into culturally responsive pedagogical approaches.

Methods

This study employs a qualitative research methodology utilizing an ethnographic approach. Ethnography serves as a methodological framework for describing and analyzing cultural phenomena (Spradley, 2016), with a particular emphasis on elucidating and comprehending cultural elements within specific communities or ethnic groups (Wissler, 1927). In this research, ethnography is applied to investigate the cultural and mathematical foundations of the Chinese zodiac system in the Chinese calendar. The study specifically focuses on identifying arithmetic patterns that govern the determination of zodiac signs and their cyclical rotations. This approach establishes a connection between the cultural significance of the Chinese zodiac and the underlying mathematical structures embedded in its calculations, thereby aligning with the broader objective of integrating ethnomathematics with arithmetic sequences in educational contexts.

To ensure the validity and reliability of the ethnographic data, multiple strategies were implemented. First, data triangulation was conducted by gathering information from various sources, including interviews with cultural experts, calendar specialists, and educators with expertise in the Chinese zodiac and its mathematical underpinnings. Second, peer debriefing was employed to validate data interpretations and minimize potential researcher bias. Third, member checking was conducted by presenting preliminary findings to key informants to confirm the accuracy and authenticity of the interpretations (Phillippi & Lauderdale, 2018). These methodological rigor techniques enhance the credibility and representativeness of the collected data.

The ethnographic approach in this study is specifically designed to explore the intersection of mathematics and cultural practices. Fieldwork included direct observations of cultural activities associated with the Chinese zodiac, such as calendar-based celebrations and consultations regarding zodiac signs. Additionally, in-depth interviews were conducted to examine how individuals conceptualize and apply arithmetic sequences in determining zodiac signs based on birth year cycles. Thematic analysis was utilized to identify recurring patterns within the data, particularly the systematic application of arithmetic progressions in year cycles

and their cultural significance. This analytical approach facilitated a comprehensive examination of the interplay between mathematical structures and cultural traditions, yielding a nuanced understanding of the topic (Bawden & Robinson, 2016). By synthesizing cultural insights with mathematical analysis, this study presents an innovative perspective on the role of ethnomathematics in enhancing mathematics education.

This study was conducted at Vihara Dharmayana, situated on Blambangan Street, Legian, Kuta District, Badung Regency, Bali. The selection of this research site was based on several considerations. First, the researcher's familiarity with the location, facilitated by frequent visits, ensured a deeper contextual understanding. Second, Vihara Dharmayana serves as a significant place of worship that attracts not only the Chinese-Indonesian community but also indigenous Balinese individuals practicing Buddhism and Hinduism. This diverse cultural and religious engagement made it an ideal setting for exploring the intersection of mathematical concepts and cultural traditions. Additionally, the Vihara is widely recognized for its welcoming environment and strong ties with the local community, factors that contributed to fostering a positive research atmosphere. These considerations were instrumental in facilitating effective data collection and establishing rapport with key informants, thereby enhancing the overall efficiency and effectiveness of the study.

The population in this study comprises all years within the Chinese calendar system. However, due to practical constraints related to funding, manpower, and time, a selective sampling approach was adopted (Turner, 2020). The sample consists of data spanning from 1960 to 2025, as documented in Complete Book of Zodiac and Feng Shui by Santosa (2018). This specific time frame was chosen to ensure a balance between historical significance and contemporary applicability, encompassing multiple cycles of the Chinese zodiac to identify potential arithmetic patterns across generations. The selection of years aligns with the 12-year zodiac cycle, providing a robust dataset for analyzing trends and validating computational models. This sampling strategy ensures that the study captures both traditional interpretations and modern adaptations of the Chinese zodiac, thereby maintaining the relevance and accuracy of the findings within the broader scope of ethnomathematics research.

In conducting ethnographic exploration, researchers begin by addressing four fundamental questions that encapsulate the core principles of ethnography: “Where to start looking?”, “How does it look?”, “How to recognize that something is significant?”, and “How to understand what it is?” (Prahmana & D’Ambrosio, 2020; Pathuddin et al., 2023). These guiding questions serve as the foundation for structuring the research stages, as outlined in Table 1.

Table 1. Ethnographic Research Design

General Questions	Initial Answers	Starting Point	Specific Activity
Where to start looking?	In the calculation of the Chinese zodiac and elements by the Chinese community, there are	Cultural Perspective	Reviewing literature on the Chinese zodiac and its elements; conducting interviews with

	significant mathematical practices involved.		knowledgeable informants.
How does it look?	Investigate aspects of the calculation process for the Chinese zodiac and its elements that are related to mathematical concepts.	Alternative thinking	Examining the mathematical principles embedded in these calculations.
What is it?	Evidence	Philosophical mathematics	Identifying the characteristics of calculating the Chinese zodiac and its elements in the Chinese calendar related to mathematical concepts. The research results show that in calculating the Chinese zodiac and its elements, the Chinese community applies mathematical concepts that can be seen from the elements of knowledge used in everyday life.
What does it mean?	The significant value of culture and mathematics.	Anthropological Perspective	Explain the relationship between the two systems of mathematical and cultural knowledge, and clarify the mathematical concepts involved in the calculation of the Chinese zodiac and its elements for the Chinese community.

Data collection was conducted through field studies and in-depth interviews with Mr. Made Wijaya, the manager of Vihara Dharmayana, located on Blambangan Street, Legian, Kuta District, Badung Regency. The primary objective of this data collection was to gain a comprehensive understanding of how beliefs related to the Chinese zodiac and its elements influence the daily lives of the local community. Additionally, the study sought to examine the

methodologies employed by the community in determining their zodiac signs and associated elements.

The collected data was systematically analyzed to explore the interrelationship between mathematical knowledge systems and the cultural framework of the Chinese zodiac. This analysis aimed to identify the mathematical principles embedded in the computation of zodiac signs and elements. The findings derived from this investigation are subsequently presented in the results section of this study.

Results and Discussion

This study aims to explore the relationship between the Chinese zodiac system and arithmetic progression patterns. By identifying this relationship, it becomes possible to formulate a mathematical representation that can systematically describe the cyclical nature of the Chinese zodiac. Understanding this connection is significant, as it not only provides insights into the recurring patterns within the zodiac system but also highlights the role of mathematics in analyzing cultural phenomena.

Determining of the Chinese Zodiac

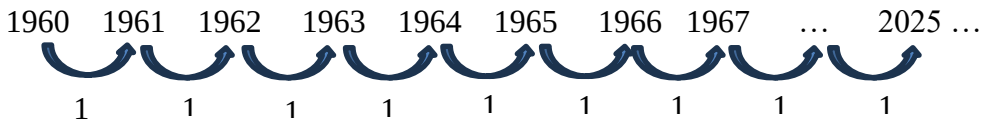
The Chinese zodiac consists of 12 animal symbols, each of which originates from ancient Chinese folklore and is believed to embody distinct personality traits and characteristics (Bai, 2021; Xue-jing, 2012). The sequence of these zodiac animals follows a fixed order, deeply rooted in traditional narratives that hold substantial cultural significance. This unchanging cyclic pattern serves as the basis for mathematical models used to determine an individual's zodiac sign based on birth year rotations. By examining the intersection of cultural traditions and mathematical structures, this study seeks to identify arithmetic patterns that not only simplify the calculation of zodiac signs but also illustrate how mathematical principles can be applied to cultural contexts. Table 2 presents the sequence of the 12 Chinese zodiac signs, mapped to specific birth years from 1960 to 2025, based on the dataset utilized in this study.

Table 2. Sequence of Chinese Zodiac Years

Sequence	Zodiac	Years					
1	**Rat** (鼠, *Shǔ*)	1960	1972	1984	1996	2008	2020
2	**Ox** (牛, *Niu*)	1961	1973	1985	1997	2009	2021
3	**Tiger** (虎, *Hǔ*)	1962	1974	1986	1998	2010	2022
4	**Rabbit** (兔, *Tù*)	1963	1975	1987	1999	2011	2023
5	**Dragon** (龙, Lóng)	1964	1976	1988	2000	2012	2024
6	**Snake** (蛇, *Shé*)	1965	1977	1989	2001	2013	2025
7	**Horse** (马, Mǎ)	1966	1978	1990	2002	2014	
8	**Goat** (羊, *Yang*)	1967	1979	1991	2003	2015	
9	**Monkey** (猴, Hóu)	1968	1980	1992	2004	2016	

10	**Rooster** (鸡, *Jī*)	1969	1981	1993	2005	2017
11	**Dog** (狗, *Gǒu*)	1970	1982	1994	2006	2018
12	**Pig** (猪, *Zhū*)	1971	1983	1995	2007	2019

The first column in Table 2 illustrates a structured numerical progression in which each successive zodiac sign corresponds to a one-year increment from the preceding year. This pattern is evident in the consecutive transitions from 1960 to 1961, 1961 to 1962, and continuing sequentially through 2024 to 2025:



This observed regularity suggests that the Chinese zodiac follows an arithmetic sequence. However, it is important to note that the Chinese calendar is based on a lunar cycle, which may introduce variations in zodiac sign determination. Specifically, individuals born in the early months of a given year, before the Lunar New Year, may have a zodiac sign corresponding to the previous year rather than the current one. Consequently, accurate zodiac sign identification necessitates careful consideration of both the birth year and the exact date of the Lunar New Year transition.

Arithmetic Sequence

Definition:

An arithmetic sequence is a sequence in which the difference or gap between two consecutive terms remains constant or consistent (Coman, 2016). Mathematically, an arithmetic sequence can be represented as follows:

$$U_1, U_2, U_3, U_4, U_5, \ldots U_n$$

Each pair of consecutive terms in an arithmetic sequence exhibits the same difference, leading to the general formulation:

$U_1 = a$

$U_2 = U_1 + 1b$

$U_3 = U_2 + b = U_1 + 2b$

$U_4 = U_3 + b = U_1 + 3b$

…

$Un = a + (n-1)b$

If $U_1, U_2, U_3, U_4, U_5, \ldots U_n$ are the terms of an arithmetic sequence, then the formula for the *n*-th term of the sequence is:

$$\boxed{Un = a + (n-1)b}$$

Where:

Un = the *n*-th term
a = U_1 = the first term of the arithmetic sequence
b = the common difference of the arithmetic sequence (Li, 2019)

If we adjust the formula for the arithmetic sequence, with the first term $a = 1960$ and the common difference $b = 1$, we can obtain the value of *n* (the term number being sought) as follows:

$Un = a + (n - 1)b$
Substituting $a = 1960$ and $b = 1$:
$Un = 1960 + (n - 1)1$
$Un = 1960 + n - 1$
$Un = 1959 + n$

Therefore, the value of *n* (the term number being sought) is:
$n = Un - 1959$
Where:
Un = birth year
a = first year
b = the difference or interval between the first year and the next year.

Given that there are 12 Chinese zodiac animals, it takes 12 years for the same Chinese zodiac to repeat. For example, the Rat in Chinese zodiac will recur in the following years:

1960 1972 1984 1996 2008 2020

12 12 12 12 12

The Chinese zodiac has a 12-year repeating cycle, with each year associated with one of the 12 zodiac animals. Therefore, to determine a person's Chinese zodiac in a specific year, it is necessary to calculate the position of that year within the repeating 12-year cycle. Modular arithmetic allows for the efficient calculation of this position.

Modular Arithmetic

Definition:
Let *n* integer and m integer be greater than zero. The operation $n \ mod \ m$ gives a remainder when *n* is divided by m. In other words, $n \ mod \ m = r$ such that $n = mq + r$, where $0 \leq r < m$ (Pathuddin et al., 2023).

Let n = Birth year $- 1959$, based on the closure property of integers under subtraction:

Birth year $\in Z$ (1)
$1959 \in Z$ (2)

From Equations (1) dan (2) it can be concluded that $n \in Z$ and reciprocally $12 \in Z$. Therefore, because $n \in Z$ and $12 \in Z$, based on that definition, the determination of Chinese zodiac in the Chinese calendar can be stated as follows:

$n \ mod \ 12 = r$, such that $n = 12q + r, 0 \leq r < 12$ (3)

Where:
r = remainder of division
n = birth year $- 1959$, $n \in Z$
q = quotient

The following is an example of determining the Chinese zodiac in the Chinese calendar:
When the year is 2019, then the following is obtained:
$n = 2019 - 1959$
$n = 60$

Substitute n into equation (3):
$n \ mod \ 12 = r$
$60 \ mod \ 12 = 0$ or can be written $60 = 12 \cdot 5 + 0$

Based on the modular arithmetic calculation, it is obtained that if n is divided by 12, there is no remainder or 0. In Table 2, the 0 th order of the Zodiac is the pig, which means that the year 2019 is the year of the pig in the Chinese calendar. Here are some examples of applying modular arithmetic to determine Chinese zodiac in the Chinese calendar, presented in Table 3.

Table 3. Application of modular arithmetic to determine Chinese zodiac

Birth Year	$\boldsymbol{n}$ $(\boldsymbol{birth\ year - 1959})$	$\boldsymbol{n \ mod \ 12 = r}$ **(n = q + r)**	**Chinese zodiac**
2020	$2020 - 1959 = 61$	$61 \ mod \ 12 = \mathbf{1}$ Since there $q = 5$ such that $61 = 12 \cdot 5 + 1$	Rat
2021	$2021 - 1959 = 64$	$62 \ mod \ 12 = \mathbf{2}$ Since there $q = 5$ such that $62 = 12 \cdot 5 + 2$	Ox
2022	$2022 - 1959 = 63$	$63 \ mod \ 12 = \mathbf{3}$ Since there $q = 5$ such that $63 = 12 \cdot 5 + 3$	Tiger
2023	$2023 - 1959 = 64$	$64 \ mod \ 12 = \mathbf{4}$ Since there $q = 5$ such that $64 = 12 \cdot 5 + 4$	Rabbit
2024	$2024 - 1959 = 65$	$65 \ mod \ 12 = \mathbf{5}$ Since there $q = 5$ such that $65 = 12 \cdot 5 + 5$	Dragon

2025	$2025 - 1959 = 66$	$66\ mod\ 12 = \mathbf{6}$ Since there $q = 5$ such that 66 = 12 · 5 + 6	Snake
2026	$2026 - 1959 = 67$	$67\ mod\ 12 = \mathbf{7}$ Since there $q = 5$ such that 67 = 12 · 5 + 7	Horse
2027	$2027 - 1959 = 68$	$68\ mod\ 12 = \mathbf{8}$ Since there $q = 5$ such that 68 = 12 · 5 + 8	Goat
2028	$2028 - 1959 = 69$	$69\ mod\ 12 = \mathbf{9}$ Since there $q = 5$ such that 69 = 12 · 5 + 9	Monkey
2029	$2029 - 1959 = 70$	$70\ mod\ 12 = \mathbf{10}$ Since there $q = 5$ such that 70 = 12 · 5 + 10	Rooster
2030	$2030 - 1959 = 71$	$71\ mod\ 12 = \mathbf{11}$ Since there $q = 5$ such that 71 = 12 · 5 + 11	Dog
2031	$2031 - 1959 = 72$	$72\ mod\ 12 = \mathbf{0}$ Since there $q = 6$ such that 72 = 12 · 6 + 0	Pig

From this pattern, it is evident that determining the Chinese zodiac sign involves a straightforward yet effective mathematical approach. This process highlights the application of fundamental arithmetic concepts, such as subtraction and the modulo operation, in understanding and mapping complex cultural systems.

Determination of Elements

Elements serve as fundamental components that enhance the understanding of the characteristics within the Chinese zodiac. In Chinese astrology, five elements—metal, wood, water, fire, and earth—are integrated with the zodiac signs. Understanding these elements provides deeper insight into the traits and attributes associated with each zodiac sign, as well as the dynamic interactions between elements that influence an individual's fate and personality in Chinese astrology. Table 4 presents the sequential arrangement of the five elements, aligned with the Gregorian calendar from 1960 to 2025 (Lau, 2005).

Table 4. Order of Elements

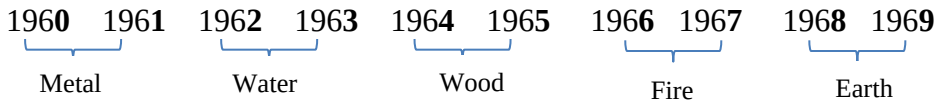
Order	Elements				
	Metal (1)	**Water (2)**	**Wood (3)**	**Fire (4)**	**Earth (0)**
Year	**1960**	1962	1964	1966	1968
	1961	1963	1965	1967	1969
	1970	1972	1974	1976	1978
	1971	1973	1975	1977	1979
	1980	1982	1984	1986	1988
	1981	1983	1985	1987	1989
	1990	1992	1994	1996	1998
	1991	1993	1995	1997	1999
	2000	2002	2004	2006	2008
	2001	2003	2005	2007	2009
	2010	2012	2014	2016	2018
	2011	2013	2015	2017	2019
	2020	2022	2024		
	2021	2023	**2025**		

There are two ways to determine the element in the zodiac sign from someone's year of birth, namely:

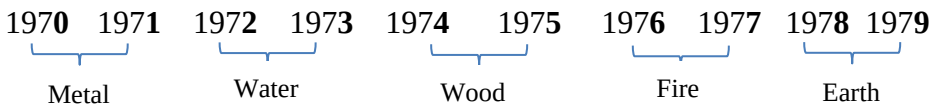
Using Number Patterns

Number patterns are sequences of numbers that follow a specific mathematical relationship. Understanding these patterns enables the prediction of subsequent numbers in a sequence, the identification of underlying mathematical structures, and the resolution of various mathematical problems.

Referring to Table 4, an analysis of the sequence of elements across different years reveals a discernible pattern, which can be interpreted as follows:
First and second row:



Third and fourth rows:



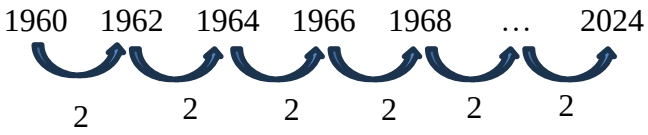
This pattern illustrates the consistent correlation between the last digit of a person's birth year and the corresponding element in the Chinese zodiac system:

Metal : Years ending in 0 or 1
Water : Years ending in 2 or 3
Wood : Years ending in 4 or 5
Fire : Years ending in 6 or 7
Earth : Years ending in 8 or 9

Recognizing this pattern simplifies the process of determining an individual's zodiac element based on their birth year. For example, a person born in 1995 has a birth year ending in 5, indicating that their element is wood. However, the relationship between elements and zodiac signs extends beyond numerical patterns. In Chinese astrology, each zodiac sign is cyclically associated with one of the five elements—wood, fire, earth, metal, and water—further shaping an individual's personality and characteristics. While the zodiac sign defines specific behavioral tendencies, the corresponding element introduces additional attributes; for instance, wood signifies growth and creativity. Examining this interplay between zodiac signs and elements provides deeper insight into how these cultural systems construct personality frameworks and life patterns, enriching the mathematical and philosophical understanding of Chinese astrology.

Using Arithmetic Formula

The arithmetic formula can be utilized in this context by analyzing the sequential pattern of changes in Chinese zodiac elements from one year to the next. Observing the first row of Table 4, it is evident that there is a consistent difference of 2 years between consecutive elements. This suggests that the pattern follows an arithmetic progression, where each subsequent element is associated with an increment of 2 years. Based on this pattern, the sequence of years corresponding to the Chinese zodiac elements is as follows:



In this arithmetic sequence, the first term (a) represents the year 1960, and the common difference (b) between consecutive terms is 2. Accordingly, the general formula for this arithmetic sequence can be expressed as:

$$Un = a + (n - 1)b$$

Where:

$Un =$ birth year for the n th term in the sequence,
$a = U_1 =$ birth year for the first term in the sequence (1960),
$n =$ order of the term in the sequence, and
$b =$ difference between two consecutive terms in the sequence (2).

Thus, the value of n (the order of the term sought) is:

$$Un = 1960 + (n - 1)2$$
$$Un = 1960 + 2n - 2$$
$$Un = 1958 + 2n$$
$$\boxed{n = \frac{Un - 1958}{2}}$$

When calculating the zodiac element based on the birth year using the arithmetic sequence formula, it is essential to recognize that the resulting value of n may not always be a whole number. Since the Chinese zodiac system associates each year with a distinct element, any fractional values of n are rounded down to the nearest whole number. This approach ensures consistency in the assignment of elements.

For example, if an individual was born in 2017, the computed value of n would be 29.5. To align with the cyclical nature of the five-element system, which does not accommodate fractional values, n is rounded down to 29. This process guarantees that each year corresponds to a singular, well-defined element, eliminating any ambiguity in classification. The necessity of rounding arises from the discrete nature of the Chinese zodiac, where each year is explicitly associated with one element. Clarifying this mathematical adjustment reinforces the logical coherence of the calculation and its alignment with both cultural traditions and mathematical principles.

Additionally, since the Chinese zodiac consists of five elements (Mahdihassan, 1989), determining the element associated with a specific birth year requires further calculations involving modular arithmetic. This method, similar to the approach used to identify the Chinese zodiac sign, ensures accurate classification within the recurring five-element cycle.

Let $n = \frac{(U_n - 1958)}{2}$ based on the closure property of integers under subtraction:

$U_n \in Z$ (1)

$1958 \in Z$ (2)

From Equations (1) and (2), it can be concluded that $n \in Z$ and vice versa, $5 \in Z$. Since $n \in Z$ and $5 \in Z$, based on that definition, the determination of the Chinese zodiac element can be expressed as follows:

$n \bmod 5 = r$, sehingga $n = 5q + r$, $0 \leq r < 5$ (3)

Where:

r = remainder of division

$n = \frac{(\text{birth year} - 1958)}{2}$, $n \in Z$

q = quotient

Here's an example of determining the element in the Chinese zodiac. If this year is 2018, then according to the formula, we obtain the value of n as follows:

$$n = \frac{(2018 - 1958)}{2}$$
$$n = \frac{60}{2}$$
$$n = 30$$

Substituting n=30 into the formula gives (3):
$n \ mod \ 5 = r$
$30 \ mod \ 5 = 0$ or it can be written as $30 = 5 \cdot 6 + 0$

From the division result, the year 2018 has no remainder, which means according to Table 4, the Chinese zodiac element for the 0 th order is Earth. Therefore, the year 2018 is a year with the Earth element. Some other examples of using modular arithmetic to determine the Chinese zodiac element are presented in the following Table 5.

Table 5. Using Modular Arithmetic to Determine the Chinese zodiac Element

Year	$\frac{n}{(U_n - 1958)}{2}$	$n \ mod \ 5 = r$ (n = mq + r)	Element
2019	$\frac{2019 - 1958}{2} = 30$	$30 \ mod \ 5 = 0$ Since there $q = 6$ such that $30 = 5 \cdot 6 + 0$	Earth
2020	$\frac{2020 - 1958}{2} = 31$	$31 \ mod \ 5 = 1$ Since there $q = 6$ such that $31 = 5 \cdot 6 + 1$	Metal
2021	$\frac{2021 - 1958}{2} = 31$	$31 \ mod \ 5 = 1$ Since there $q = 6$ such that $31 = 5 \cdot 6 + 1$	Metal
2022	$\frac{2022 - 1958}{2} = 32$	$32 \ mod \ 5 = 2$ Since there $q = 6$ such that $32 = 5 \cdot 6 + 2$	Water
2023	$\frac{2023 - 1958}{2} = 32$	$32 \ mod \ 5 = 2$ Since there $q = 6$ such that $32 = 5 \cdot 6 + 2$	Water
2024	$\frac{2024 - 1958}{2} = 33$	$33 \ mod \ 5 = 3$ Since there $q = 6$ such that $33 = 5 \cdot 6 + 3$	Wood

2025	$\frac{2025-1958}{2}=33$	$33\ mod\ 5=3$ Since there $q=6$ such that 33 = 5 · 6 + 3	Wood
2026	$\frac{2026-1958}{2}=34$	$34\ mod\ 5=4$ Since there $q=6$ such that 34 = 5 · 6 + 4	Fire
2027	$\frac{2027-1958}{2}=34$	$34\ mod\ 5=4$ Since there $q=6$ such that 34 = 5 · 6 + 4	Fire
2028	$\frac{2028-1958}{2}=35$	$35\ mod\ 5=0$ Since there $q=7$ such that 35 = 5 · 7 + 0	Earth

This pattern highlights that determining the Chinese zodiac follows a straightforward yet effective mathematical process, utilizing fundamental arithmetic concepts such as subtraction and the modulo operation. This demonstrates the practical application of mathematics in deciphering and mapping out complex cultural systems.

Integrating this mathematical model into educational contexts could enhance learning experiences by using culturally relevant examples to teach arithmetic operations, thereby fostering students' interest and engagement. For instance, educators could incorporate the Chinese zodiac as a case study in mathematics lessons to illustrate how fundamental mathematical principles are embedded within cultural traditions, promoting interdisciplinary learning.

Furthermore, this model has potential applications in cultural heritage preservation. Developing interactive tools or applications that employ arithmetic-based calculations to educate users about the Chinese zodiac system could enhance public understanding of its significance and intricacies. Such innovations could bridge cultural awareness and mathematical literacy, making this research more accessible and applicable to real-world educational and heritage contexts.

Interview

A structured interview was conducted with a key informant, the caretaker of Vihara Dharmayana, to gain insights into the historical background, visitor demographics, and cultural significance of the temple. The informant revealed that the temple, commonly referred to as a "vihara" by visitors, was established in 1876 and has undergone significant improvements over time. The temple receives daily visitors, with a notable increase in attendance during major celebrations such as Chinese New Year. The visitors come from diverse backgrounds, including members of the Chinese community and indigenous Balinese people. The results of the interview are as follows:

Researcher : "When was Vihara Dharmayana established?"

Informant	:	"Visitors here usually refer to it as a temple, so this temple was founded in 1876 but it wasn't as good as it is now before."
Researcher	:	"How many visitors are there here every day?"
Informant	:	"There are always people coming to pray here every day, it gets crowded during holidays like Chinese New Year."
Researcher	:	"Who are the visitors of this temple?"
Informant	:	"People from various backgrounds, many Chinese people come, and also many native Balinese people."
Researcher	:	"Do people who come here only come to pray?"
Informant	:	"No, besides praying, people also come to ask for auspicious dates for weddings, starting a business, and purifying themselves especially when their year is unlucky or *ciong*."
Researcher	:	"Where can people find out their Chinese zodiac based on their birth year?"
Informant	:	"They can ask here because we have books related to it, or they can also search online, but sometimes there are many mistakes."
Researcher	:	"How do we calculate our Chinese zodiac?"
Informant	:	"There are 12 Chinese zodiacs consisting of 12 animals: pig, rooster, tiger, dog, monkey, goat, horse, snake, dragon, ox, rat, rabbit. Remember that these animals are arranged based on stories from the past. These 12 zodiac signs will continue to rotate, for example, this year 2023 is the year of the water rabbit, in 2035 it will definitely be the year of the rabbit again but not the year of the water rabbit."
Researcher	:	"What do you mean by that?"
Informant	:	"So, besides the Chinese zodiac from those animals, there are also the elements, 5 in total: water, fire, earth, metal, wood. These elements also rotate around the Chinese zodiac. Do you know gears that rotate together like a wheel? It's like that between the Chinese zodiac and the elements."
Researcher	:	"Earlier it was explained that this year 2023 is the year of the water rabbit, but why is it not the year of the rabbit in 2035?"
Informant	:	"That's right, 2035 is still the year of the rabbit but the year of the wood rabbit. Yes, because of the elements that I explained earlier."
Researcher	:	"Okay, so that means the elements have to rotate twice around all the Chinese zodiac?"
Informant	:	"Correct, there are 12 Chinese zodiac and 5 elements, so they have to rotate twice, and even then, it's still not enough."
Researcher	:	"Alright, thank you."
Informant	:	"You're welcome."

The findings from this interview underscore the intricate relationship between cultural traditions and mathematical structures, providing a foundation for the development of mathematical models that integrate traditional belief systems with mathematical reasoning. This study identified an underlying mathematical framework based on number patterns and modular

arithmetic, offering a novel perspective on how structured cultural systems can be analyzed through mathematical principles.

Integrating this mathematical model into mathematics education can enhance student engagement by connecting abstract mathematical concepts—such as arithmetic sequences, cyclical patterns, and modular calculations—with real-world cultural contexts. By embedding cultural narratives within mathematical instruction, educators can foster a deeper appreciation for both mathematics and cultural heritage. This interdisciplinary approach not only enriches learning experiences but also demonstrates the relevance of mathematical concepts beyond conventional academic settings, ultimately improving student learning outcomes and promoting cross-disciplinary thinking.

Conclusion

This study provides a significant contribution by establishing a connection between mathematics and cultural traditions, specifically in determining the Chinese zodiac and its elements. The findings highlight the mathematical principles embedded in cultural practices, demonstrating how arithmetic sequences and modulus operations can be applied to calculate the Chinese zodiac based on birth years. This integration not only enhances the practical understanding of zodiac determination but also expands the theoretical framework by illustrating how mathematical concepts intersect with cultural heritage. By revealing these mathematical underpinnings, the study opens new avenues for interdisciplinary research, encouraging the exploration of mathematics within various cultural contexts. Furthermore, these insights can serve as a foundation for developing educational materials that integrate cultural narratives with mathematical learning, making abstract mathematical concepts more tangible and engaging for learners.

Despite its contributions, the study also identifies a critical gap in public knowledge regarding the mathematical calculations behind the Chinese zodiac and its elements. Many individuals rely on traditional methods or simplified interpretations without understanding the underlying mathematical principles. To bridge this gap, targeted educational initiatives should be implemented, such as workshops, interactive seminars, and digital learning resources tailored for diverse audiences, including students, educators, and cultural enthusiasts. The development of accessible multimedia content, such as instructional videos, infographics, and interactive applications, could further enhance public engagement and comprehension. Additionally, collaboration with cultural organizations, educational institutions, and digital content creators could amplify the dissemination of these materials, ensuring a broader reach and fostering a deeper appreciation for the mathematical foundations of cultural traditions.

Nevertheless, this research has certain limitations that should be addressed in future studies. The study primarily focuses on zodiac determination based on birth years, without considering additional factors such as birth dates and months, which may influence zodiac element classifications in certain traditions. Moreover, the methodology could be expanded to incorporate a larger and more diverse dataset, allowing for a more comprehensive analysis of mathematical patterns across different cultural interpretations. Future research could explore

alternative mathematical models or computational approaches to refine the accuracy of zodiac calculations. Additionally, comparative studies across different cultural zodiac systems could offer valuable insights into the universal application of mathematical principles in cultural traditions. By addressing these limitations, future research can further strengthen the interdisciplinary connection between mathematics and cultural studies, contributing to both mathematical education and cultural preservation.

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Coflicts of Interest

The authors affirm that there are no ethical conflicts, such as plagiarism, misconduct, data fabrication or falsification, duplicate publication or submission, and redundancies, related to the publication of this manuscript.

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