AXIOM : Jurnal Pendidikan dan Matematika
(2024) Volume 13, No. 2, Page 231-243
https://doi.org/10.30821/axiom.v13i2.22118

The Parhalaan of the Batak Ugamo Malim in the arithmetic context

Ruth Mayasari Simanjuntak*, **Agusmanto JB Hutauruk, Efron Manik**
Universitas HKBP Nommensen, North Sumatra, Indonesia
*Correspondence: ruthmayasarisimanjuntak@gmail.com

Received: 18 October 2024 / Accepted: 23 December 2024 / Published Online: 31 December 2024

Abstract
The implementation of ethnomathematics approaches that connect culture and mathematics education remains limited, despite the need to bridge mathematical concepts with real-world applications rooted in local culture. The Batak Parhalaan calendar, which incorporates arithmetic computations, has not been extensively explored within mathematics education. Prior studies often focus broadly on ethnomathematics without delving into specific cultural contexts, such as traditional calendars and their relevance to learning mathematics. This study addresses this gap by investigating how the Parhalaan calendar can be integrated into mathematics instruction to enhance students' understanding of mathematical concepts. Employing a qualitative descriptive approach, this research examines the Batak Ugamo Malim tribe's calendar system, calculates Parhalaan in relation to arithmetic, and analyzes it from a mathematical perspective. The results reveal the application of modulo arithmetic in Parhalaan, specifically the modulo 7 system, which reflects the 7-day week structure. Results reveal the application of modulo arithmetic in Parhalaan, specifically the modulo 7 system, reflecting the 7-day week structure. The formula $X+Y-Z=S \bmod 7$ harmonizes the traditional Batak calendar with the Gregorian system, providing a systematic method for determining days. Integrating this concept into mathematics education strengthens problem-solving, logical reasoning, and interdisciplinary understanding. Linking mathematics with cultural traditions fosters appreciation for local heritage, broadens perspectives, and raises awareness about preserving cultural diversity, thereby enriching the educational experience for students.

Keywords: Aritmethics, Bataknese calender, Etnomathematics, Parhalaan, Ugamo Malim

How to Cite: Simanjuntak, R.M., Hutauruk, A., & Manik, E. (2024). The Parhalaan of the Batak Ugamo Malim in the arithmetic context. *AXIOM : Jurnal Pendidikan dan Matematika, 13*(2), 231-243. https://doi.org/10.30821/axiom.v13i2.22118

Introduction

The 4.0 industrial revolution is an era characterized by significant changes across all fields of life. A positive impact of the 4.0 industrial revolution is the advancement of the education sector, particularly in mathematics education. However, a negative impact is the erosion of cultural values (Yuli & Siswono, 2020). Attitudes and behaviors such as hospitality, mutual cooperation, and respect for one another are slowly eroding and may eventually disappear.

The Indonesian government has taken steps to preserve and protect national and local cultures by mandating the P5 theme (Pancasila Student Profile Strengthening Project) in the independent curriculum. Mathematics education, as a formal education, contributes to the inheritance and development of national culture. (Budi, 2020) states that mathematics is a sociocultural construction, a product of culture, and rooted in culture. Mathematics education needs to provide a bridge between everyday mathematics based on local culture and school mathematics.

An approach that can be used to explain the reality of the relationship between culture and mathematics is ethnomathematics (Septia et al., 2024; Amalia & Mariana, 2023; Sihombing & Simanjuntak, 2020; Atmaja, 2014). The goal of ethnomathematics is to contribute to both the understanding of culture and mathematics, and mainly to lead to an appreciation of the connections between the two (Fauzi, 2022). Through research, forms of ethnomathematics can be witnessed in the cultures around us. In this research, the relationship between culture and mathematics learning is explored through the Batak tribe's calendar, commonly known as Parhalaan, and its connection to calendar calculations using arithmetic.

Ugamo Malim is a belief system that worships Debata Mulajadi Nabolon, who is revered as the creator and ruler of the universe. One of the representatives of Debata Mulajadi Nabolon is the Batak king Sisingamangaraja XII (Tambunan, 2023). The Batak community, particularly the Ugamo Malim, has a divination culture in their calendar used to determine the timing of religious and customary activities among the Batak people. Parhalaan is a Batak term meaning calendar or almanac. Parhalaan is a traditional practice passed down through generations by the Ugamo Malim Batak tribe and is an integral part of Indonesia's rich and diverse cultural heritage (Afaq et al., 2022). Almost all activities of the Batak people in the past were determined based on Parhalaan. These activities were meticulously regulated by the division of hours, days, and months. In the context of arithmetic, this represents a close relationship between belief, culture, and mathematical knowledge contained within spiritual and social contexts. For the Batak community, this Parhalaan is becoming increasingly foreign, yet it is still used by Ugamo Malim (Gultom, 2010).

An approach that bridges the relationship between culture and school mathematics is ethnomathematics. In this study, the relationship between culture and mathematics learning is explored through the Batak tribe's calendar, commonly known as Parhalaan, and its connection to calendar calculations using arithmetic. This research aims to examine how the use of arithmetic becomes key in understanding natural phenomena, spiritual beliefs, and the daily lives of the Batak Ugamo Malim community (Insani et al., 2021). For instance, in the research by Nurdiansah & Artamefina (Nurdiansah & Artamefina, 2023), the Javanese calendar system was used to determine the initial planting day. Their research indicated that the Javanese community still uses tradition to determine auspicious days for farming. Similarly, Agustina et al. (Agustina et al., 2016), mentioned that the Javanese calendar system can be linked to mathematics used in daily activities. Their research highlighted that cultural and daily activities in the Javanese calendar can be integrated into mathematics learning. Utami & Sayuti (Utami & Sayuti, 2020) also explored elementary school mathematics concepts within the Javanese calendar.

In this research, modular arithmetic is employed. Modular arithmetic plays an important role in integer calculations, with the operator "mod" providing the remainder of a division. One of its applications is in the modulo calculation of ISBN numbers (Christianto, 2016) and (Lukman et al., 2018). The concept of modulo arithmetic can also be used for chord transposition and calendrical computations (Mulyadi et al., 2021; Belleza & Loquias, 2015). To expand the scope of ethnomathematics across various cultures, it is essential to conduct research on the calendar of the Batak tribe, specifically Ugamo Malim, which still uses this calendar system and relates it to arithmetic. The Parhalaan of the Batak Ugamo Malim tribe is a cultural heritage that must be preserved. Besides being a cultural heritage, it is also an intellectual wealth of our ancestors. Therefore, the author aims to research the Parhalaan of the Batak Ugamo Malim tribe.

This research addresses several empirical and theoretical issues. Empirically, the lack of research on the Batak Parhalaan calendar, particularly in the context of mathematics education, indicates insufficient attention to preserving this local culture, which is increasingly rare outside the Ugamo Malim community. Moreover, although modular arithmetic has been widely used in modern contexts such as ISBNs and music, its application in traditional calendar systems like Parhalaan remains unexplored. Integrating modular arithmetic into traditional calendar systems could enhance students' appreciation of mathematics through culturally relevant contexts.

In the midst of the Industrial Revolution 4.0 era, cultural values such as mutual cooperation and respect for customs are increasingly eroded, highlighting the importance of preserving traditions like Parhalaan to maintain cultural identity. Theoretically, the absence of models connecting Parhalaan with mathematical concepts, such as modular arithmetic, creates a gap in the ethnomathematics approach, which often lacks depth or specificity to certain cultures. Additionally, the cultural relevance in a modern context has not been extensively studied. Therefore, this research aims to demonstrate how traditions like Parhalaan remain relevant and can contribute to formal education and cultural preservation.

This research will also examine the impact and relevance of this study in a modern context, highlighting how this tradition continues to serve as a valuable cultural heritage and exploring the significance of arithmetic in understanding the world more broadly. The objectives of this research are: To understand the calendar system of the Batak Ugamo Malim tribe; To perform calculations related to the calendar system of the Batak Ugamo Malim tribe in relation to arithmetic; and To analyze the calendar system of the Batak tribe from a mathematical perspective. In this research, the problem-solving approach is through literature review exploration. The exploration conducted includes understanding basic arithmetic concepts, identifying questions, and considering and designing the most effective arithmetic strategy, which is modular arithmetic.

Methods

In this study, the type of research used is descriptive research with a qualitative approach. Qualitative research is a type of research that produces findings that cannot be achieved using statistical procedures (Murdiyanto, 2020). This research employs an ethnographic approach, which involves efforts to explain culture or its aspects. This approach aims to obtain in-depth descriptions and analyses of culture based on intensive field research and literature review. The research period starts in May 2024, and the research location is in Medan, within the Ugamo Malim community. The subjects of this research are two community leaders of Ugamo Malim.

Research stages conducted: (1) Observation: At this stage, the researcher observes the objects and subjects of the research that have been predetermined. The purpose of this observation is to gain an initial understanding of the situation, context, or phenomenon that will be studied. This observation helps researchers identify important aspects that need to be considered in further research. (2) Instruments: Based on the initial observation results, the researcher creates research instruments, such as observation guidelines and interview guidelines. These instruments are designed to collect data relevant to the research objectives. The instruments used in this study are observation sheets and semi-structured interview sheets, which allow for flexibility in exploring information. (3) Instrument validation: Validation is conducted to ensure that the instrument created can be used effectively and produce accurate data that is relevant to the research objectives. This validation involves instrument trials, discussions with experts (expert judgment), or revisions based on received feedback. (4) Data collection: Data were collected through direct observation and interviews with the research subjects. Observations recorded relevant behaviors or events in the field, while interviews helped obtain deeper insights, opinions, or information from the research subjects. (5) Data analysis: The researcher uses data triangulation. Triangulation is employed to check the validity of the data and also to enrich the data. The triangulation methods used in this research are interviews and observations.

Result

Parhalaan Ugamo Malim calendar system

Parhalaan is one of the ancient manuscripts of the Batak Toba community that contains an almanac or calendar to determine time (Tambunan, 2023). This Parhalaan is generally inscribed on bamboo, tree bark, and bones (Frifana, 2022). In this research, the terms (names) of the days will be elucidated. In the Batak or Parhalaan calendar, numbers are not utilized; instead, specific terms are used. The naming of days in a month in the Parhalaan calendar is presented in Table 1.

Table 1. Name of Days

Day	Name	Day	Name
Day-1	Artia	Day-16	Suma ni Holom
Day-2	Suma	Day-17	Anggara ni Holom
Day-3	Anggara	Day-18	Muda ni holom
Day-4	Muda	Day-19	Boraspati na holom
Day-5	Boraspati	Day-20	Sikkora Mora Turun
Day-6	Sikkora	Day-21	Samirsa Mora Turun
Day-7	Samirsa	Day-22	Antian Ni angga
Day-8	Artia Ni Aek	Day-23	Suma Ni Mate
Day-9	Suma Ni Mangadop	Day-24	Angga Ni Begu
Day-10	Anggara Sappulu	Day-25	Muda ni Mate
Day-11	Muda Ni Mangadop	Day-26	Boraspati Nagok
Day-12	Boraspati Ni Takkup	Day-27	Sikkora Duduk
Day-13	Sikkora Purnama	Day-28	Samirsa Bulan Mate
Day-14	Samirsa Purnama	Day-29	Hurung
Day-15	Tula (Purnama)	Day-30	Ringkar

Source*: Kalender peramalan Batak (Depdikbud Proyek pengembangan permuseuman-Sumut, 1985)*

The Batak people in the past were not accustomed to the concept of counting years as we do now. They did not count years based on an annual time cycle, but they possessed deep knowledge about the lunar cycle. In Batak culture, a year consists of 12 months, each with a special name. This knowledge is closely related to nature, agriculture, and their daily activities, which are connected to the seasons, lunar cycles, and natural rhythms. Although the concept of a "year" is not explicitly counted, they still understood the annual cycle based on observed natural changes over time. The terms for the months in the Parhalaan calendar are displayed in Table 2.

Table 2. Months in Parhalaan

No	Name	Month
1	Sipaha Sada	March-April
2	Sipata Dua	April-May
3	Sipata Tolu	May-June
4	Sipata Opat	June-July
5	Sipaha Lima	July-August
6	Sipaha Onom	August-September
7	Sipaha Pitu	September-October
8	Sipaha Walu	October-November
9	Sipaha Sia	November-December
10	Sipaha Sampulu	December-January
11	Li	January-February
12	Hurung	February-March

Source: *Kalender peramalan Batak (Depdikbud Proyek pengembangan permuseuman-Sumut)*

Based on Table 2 above, the Batak people believe that the new year begins with Sipata Sada, which corresponds to March in the Gregorian calendar. Besides the term "Month" in the calendar, these months also have specific names related to natural phenomena, daily life, and Batak culture. The calculation of the Batak New Year is based on the movement of the Orion star and its setting in the western horizon. See the latest Batak year in Table 3.

Table 3. Naming based on the movement of the Orion star (constellation)

No	Names	Month
1	Marumba	9 Februari – 10 Maret
2	Mena	11 Maret – 12 April
3	Gorda	13 April – 14 Mei
4	Marsoba	15 Mei – 16 Juni
5	Nituna	17 Juni – 18 Juli
6	Makara	19 Juli – 20 Agustus
7	Babiat	21 Agustus – 22 September
8	Hania	23 September – 24 Oktober
9	Tola	25 Oktober – 26 November
10	Martiha	27 November – 28 Desember
11	Dano	29 Desember – 30 Januari
12	Harahata	31 Januari – 8 Februari

Based on Table 3 above, the Batak calendar year begins with the position of Orion in the northern sky in the west until the new year, followed by the next full moon observed from the east, which then moves to the Hala area in the eastern sky. In ancient times, the Batak people observed the relationship between the moon, stars, earth, and sun with humans inhabiting the earth. This calculation formed the basis for determining the beginning of the Batak year.

Concept of modulo arithmetic

Modulo arithmetic is a concept in mathematics that involves the division of integers while leaving a remainder. Modulo arithmetic, also known as modular or clock arithmetic, is a system in which numbers are divided by a certain number (the modulus), and the result of this operation is the remainder. Let's assume a is an integer and m is an integer greater than zero (Weaver, 2012). The operation a mod m, pronounced "a modulo m" gives the remainder of the division when a is divided by m.

Definition 1.
If m is a positive integer, then a is congruent to b modulo m (a ≡ b (mod m)) if m divides (a – b) exactly. If m does not divide (a – b) exactly, then it is said that a is not congruent to b modulo m (a ≡ b (mod m)).

Based on this definition, let a and b be integers, and m be an integer > 0, then $a \equiv b \ (mod\ m)$ if m divides $a - b$ exactly. Additionally, the congruence $a \equiv b \ (mod\ m)$ can also be expressed in the following form: $a = b + km$, where k is an integer (Rofifah, 2020). In the context of modulo arithmetic, the congruence property can also be written as follows:

$$a \equiv r \ (mod\ m) \tag{1}$$

r is the remainder of the division of a by m, which can be seen based on the following definition:

Definition 2.
If a ≡ r (mod m) with 0 ≤ r, then r is called the smallest residue of a modulo m. For this modulo m congruence, {0,1,2,…,(m-1)} is called the set of smallest residues modulo m.
(Fathiyah et al., 2022).

The concept of modulo arithmetic in the Ugamo Malim calendar

The concept of modulo arithmetic in the Ugamo Malim calendar plays an important role in determining the days. This system only uses seven number symbols, namely: 0, 1, 2, 3, 4, 5, and 6. In the modulo addition system, the mathematical concept calculates the remainder of the division of two numbers. When dividing one number by another, the result obtained from the modulo operation is not the quotient but the remainder. In the calculation of days, a modulo 7 system is used because a week consists of 7 days. For example, 1 + 2 = 3 in modulo 7, but 1 + 7 = 1 because 8 divided by 7 has a remainder of 1.

Here is the modulo 7 addition in the day system:
First day = 0; 0 + 7 divided by 7 = 1 remainder 0
Second day = 1; 1 + 7 divided by 7 = 1 remainder 1
Third day = 2; 2 + 7 divided by 7 = 7 remainder 2
And so on
Seventh day = 6; 6 + 7 divided by 7 = 7 remainder 6

Based on the results of the calculations, it will be displayed in the Table 4.

Table 4. Remaining Days

No	Day	Residu	Name
1	Day-1	0	Artia
2	Day-2	1	Suma
3	Day-3	2	Anggara
4	Day-4	3	Muda
5	Day-5	4	Boraspati
6	Day-6	5	Sikkora
7	Day-7	6	Samirsa

The number of days in the Batak calendar is 355 days, so if we look at it in the modulo 7 system, it can be calculated as 1 year = 355 mod 7 = 50 remainder 5. Therefore, if the year starts with Artia, the end of the year will fall on the day Sikkora, and so on. For example, in the year 2024, January 1, 2024, on the Batak calendar is Sikkora Day, so to see the days at the end of 2024, it would be after Sikkora, then Samirsa – Artia – Suma – Anggara – Muda. So at the end of the Batak calendar in 2024, it is Muda.
To determine a specific day, the following method can be used:

$$X + Y - Z = S \tag{2}$$

Where
X : number of years
Y : an integer spread from (X/4)
Z : number of days from the date (p + 1) to December 31
S : modulo remainder

The number of days in the Parhalaan will be displayed in the Table 5.

Table 5. Number of Days in the Parhalaan

No	Month	Number of Days
1	Sipaha Sada	30
2	Sipata Dua	30
3	Sipata Tolu	29
4	Sipata Opat	30
5	Sipaha Lima	29
6	Sipaha Onom	30
7	Sipaha pitu	30
8	Sipata Walu	30
9	Sipata Sia	29
10	Sipata Sappulu	30
11	Li	30
12	Hurung	28

The Table 5 describes the number of days in each month of the Parhalaan calendar, which consists of 12 months with a pattern of days mostly alternating between 30 and 29 days, except for the last month, Hurung, which has 28 days. Months such as Sipaha Sada, Sipata Dua, Sipata Opat, Sipaha Onom, Sipaha Pitu, Sipata Walu, Sipata Sappulu, and Li have 30 days, while Sipata Tolu, Sipaha Lima, and Sipata Sia have 29 days. The total number of days in one year of this calendar is 354 days, indicating that this system is likely based on a lunar calendar, similar to the Hijri calendar, which also has a shorter year compared to solar calendars like the Gregorian. As an example, it will be determined

1. What day does the independence day of the Republic of Indonesia, August 17, 1945, fall on in the Batak calendar?
   Using the formula X + Y – Z = S mod 7,
   we have
   X =1945
   Y =1945/4=486
   Z =the number of days from August 18 to December 31= 136
   Thus, X + Y – Z = 1945 + 486 – 136 = 2295 → 2295 mod 7 = 327 remainder 6 = 6
   The day with a remainder of 6 in Table 5 is Samirsa day. The month of August in the Batak calendar is Sipaha Lima, so August 17, 1945, in the Batak calendar is Hari Samirsa bulan Sipaha Lima Tahun 1945.
2. The inauguration of HKBP Nommensen University on October 7, 1954, what day did it fall on in the Batak calendar?
   Given:
   X = 1954
   Y = 1954 / 4 = 488.5 = 489
   Z = number of days from October 7 – December 31 = 24 + 30 + 31 = 85 = 85 mod 7 = 12 remainder 1 = 1
   The day with a remainder of 1 in the Batak calendar is Suma.
   The beginning of October in the Batak calendar is Sipaha Pitu, so October 7, 1954, in the Batak calendar is Hari Suma Bulan Sipaha Pitu Tahun 1954.

Discussion

The formula $X + Y - Z = S$ mod 7 is a straightforward method for calculating specific days in the Batak calendar based on dates in the Gregorian calendar. By using this formula, we can identify days in the Batak calendar that coincide with important dates in Indonesian history or other significant dates. The Batak calendar differs from the Gregorian calendar commonly used daily; the Batak calendar consists of days with special characteristics and does not directly align with the names of days in the Gregorian calendar. This formula has three main variables, namely Y, and Z. The variable X represents the Gregorian year to be converted, while the variable Y is the result of dividing that year by 4. This division aligns with the leap year cycle in the Gregorian calendar, where every four years an extra day is added in February to accommodate the 365.25 days in a year. In other words, dividing the year by 4 helps account for the correction resulting from leap years, making the day calculation more accurate. The value of Z, on the other hand, indicates the number of days from the calculated date until the end of the year. Thus, Z is obtained by counting the total days from the date we are examining until December 31 of the relevant year. After calculating the value $+ Y - Z$, the result is modulated by 7 to map the final result into the weekly Batak calendar system.

The next step after obtaining the result from X+Y−Z is to apply the modulus 7 operation. Using this modulus means we map the obtained number into the number system from 0 to 6, which represents the days of the week in the Batak calendar. Each remainder when divided by 7 corresponds to a specific day in the Batak calendar, which differs from the names of the days in the Gregorian calendar. In practice, this allows us to determine the day in the Batak calendar that coincides with a specific date in the Gregorian calendar. The first example of the application of this formula is on Indonesia's Independence Day, namely August 17, 1945. Using the formula $X+Y-Z=S \bmod 7$, we can determine the day in the Batak calendar for this important date. To calculate it, we input the year 1945 into variable X, so $X=1945$. Next, we calculate Y, which is the result of dividing the year 1945 by 4, yielding $Y=486$ after rounding down. Then, we calculate Z, which is the number of days from August 18 to the end of the year 1945, totaling 136 days. After all values are calculated, we substitute them into the formula: $X+Y-Z=1945+486-136=2295$. This result of 2295 is then modulated by 7 to get the final result: $2295 \bmod 7 = 6$. Based on the Batak calendar table, this remainder of 6 indicates the day of Samirsa in the Batak calendar. According to the Batak calendar, the month of August coincides with the month of Sipaha Lima, so we can conclude that August 17, 1945, falls on the day of Samirsa in the month of Sipaha Lima in the Batak calendar.

Based on the two examples above, the entire process demonstrates how the formula $X+Y-Z=S\bmod 7$ can help determine specific days in the Batak calendar based on dates in the Gregorian calendar. This conversion not only allows for marking important historical days such as Independence Day or the inauguration of important institutions, but it can also be applied to other dates deemed necessary to be adjusted to the traditional Batak calendar. The Batak calendar itself is part of the cultural wealth that has a different time calculation, so this conversion effort is also part of the appreciation and preservation of local cultural heritage. Overall, the calculation method using the formula $X+Y-Z=S \bmod 7$ is very efficient and can be easily applied with basic calculations. As long as there is a reference table showing the relationship between the modulus remainder and the names of the days in the Batak calendar, conversion can be done for various dates in the Gregorian calendar. This system also demonstrates how modular arithmetic and calendar calculations can be integrated to understand traditional calendar systems that have unique logic and calculations, such as the Batak calendar. This is in line with the results of research conducted by (Yuniawatika, 2015) which applies modulo arithmetic to the use of Javanese Primbon. The formula $X+Y-Z=S\bmod 7$ to determine the day in the Batak calendar based on the date in the Gregorian calendar has several limitations. First, the accuracy of this formula depends on historical data and references that may not fully align with local tradition variations. Additionally, the assumption that the relationship between the Batak and Gregorian calendars is linear may overlook the astronomical or traditional cycle aspects underlying the Batak calendar. The mod 7 system used to map the results into Batak days also relies on specific reference tables, which could lead to differences in results if there are variations in the interpretation of day names in different regions. The implications of the limitations of the formula $X+Y-Z=S\bmod 7$ for future research includes several important aspects. Further research is needed to improve the accuracy and validity of this formula by considering the traditional and astronomical variations that may underlie the Batak calendar. The development of more complex models, for example by integrating astronomical cycle calculations or local traditions, could provide a deeper and more authentic representation. Additionally, comparative studies between the Batak calendar and other calendars, such as the Javanese or Balinese calendars, can provide broader insights into the logical patterns of traditional calendars in Indonesia. This finding is in line with the statement (Rahma et al.,

2020) that to predict calendar calculations, one can use the modulo 7 system, which has very easy calculations. The same research (Rahma et al., 2021) can also predict religious holidays by applying the modulo 7 system using an appropriate algorithm so that it no longer requires manual calculations, the calculation results and the determination of the day are also correct, this can be proven by looking at and matching the results of the calendar.

Ethnomathematics, as a study in uncovering the mathematical activities within the Batak calendar system, reveals several fascinating aspects and can foster a more realistic and culturally rich mathematical concept. The mathematical activities embedded in the development and application of the Batak calendar are deeply intertwined with its historical and cultural origins. The Batak calendar, with its unique system of days and months, reflects the observational and computational skills of the Batak ancestors, who integrated their understanding of astronomy and arithmetic into a practical and ceremonial framework. This aligns with findings by researchers such as Angerler (2021) who highlight that traditional Batak communities possessed advanced knowledge systems for timekeeping and agricultural cycles. Such knowledge demonstrates that the Batak people were not only adept at managing daily life but also at preserving cultural wisdom through mathematical practices that remain significant today.

Future research could focus on compiling a historical database documenting the relationship between the Gregorian calendar and the Batak calendar, including a more comprehensive and widely agreed-upon reference table. This effort can simplify the conversion process and increase trust in the calculation results. Technological approaches such as algorithmic programming or digital-based applications can be utilized to automate the calendar conversion process, making the results more accessible to the general public.

With this research, it is hoped that the cultural elements in Indonesia will be preserved, especially local cultures, to enhance appreciation for local traditions and prevent them from being lost or appropriated by others. Mathematics learning should be related to real life or students' daily activities. One approach is through mathematics learning based on the Batak calendar, providing a contextual and meaningful application of mathematics. Integrating mathematical concepts in the Batak calendar into education can help preserve local culture while demonstrating to students that their ancestors were thinkers capable of creating a complex calendar system rooted in mathematical calculations and careful astronomical observations.

Conclusion

Based on the research results and discussion, the author draws the following conclusions: The Parhalaan calendar system of the Batak Ugamo Malim tribe uniquely divides daily and monthly time, centered on natural cycles and rhythms observed from their surroundings. In a day, Parhalaan divides time into 24 hours, but those hours do not directly follow the concept of time in the Gregorian calendar. The day in the Parhalaan calendar starts at 6:00 AM (sunrise) and lasts until 6:00 AM the next day, with specific terms according to daily activities.

In addition to the daily time division, the naming of days in a month in the Parhalaan calendar also consists of specific terms amounting to 30 days. The names of the days not only indicate the order of the days but are also sometimes related to activities or natural signs relevant in Batak culture.

The Parhalaan calendar system is closely related to the concept of arithmetic, particularly modular arithmetic. Using modulo 7 arithmetic, the Batak people associate each day of the week with the remainder of division. Since a week consists of seven days, every day calculation in the Parhalaan calendar can be done by dividing the remainder of the day by the number 7. In this modulo calculation, the first day in the Batak calendar (Artia) is considered to have a remainder of 0, the second day (Suma) has a remainder of 1, and so on until the seventh day (Samirsa), which has a remainder of 6.

With this approach, every Gregorian date can be linked to the days in the Batak calendar with quite accurate results. From a mathematical perspective, the Parhalaan calendar system of the Batak tribe demonstrates a unique integration of modular arithmetic and traditional culture. Using the formula $X+Y-Z = S \bmod 7$, this system utilizes modular arithmetic to align the traditional Batak calendar cycle with the Gregorian calendar, introducing a systematic method for determining days.

Declarations

Author Contribution	:	RMS: Conceptualization, Writing - Original Draft, Editing and Visualization. AH: Writing - Review & Editing, Formal analysis, and Methodology. EM: Validation and Supervision.
Conflict of Interest	:	The authors declare no conflict of interest.

References

Afaq, A.L., Ahmad, A.F., Fatmawati, A., & Qulub, S.T. (2022). Implementasi taqwim standar indonesia sebagai pemersatu kalender masyarakat indonesia. *Al-Afaq: Jurnal Ilmu Falak dan Astronomi*, *4*(2), 157–180. https://doi.org/10.20414/afaq.v4i2.4166

Agustina, L.O., Sunardi, & Susanto. (2016). Etnomatematika pada penanggalan Jawa terkait Aritmatika di desa Yosomulyo. *Kadikma*, *7*(1), 22–23.

Amalia, R.D., & Mariana, N. (2023). Eksplorasi konsep matematika sekolah dasar pada penanggalan jawa dalam bingkai etnomatematika. *JPGSD: Jurnal Penelitian Pendidikan Guru Sekolah Dasar*, *11*(7), 1525–1535. https://ejournal.unesa.ac.id/index.php/jurnal-penelitian-pgsd/article/view/53930

Angerler, J. (2021). Indigenous knowledge about time-keeping : astronomical aspects of the batak calendar. *Indigenous Knowledge*, *1*(1), 1–5. https://doi.org/10.24198/ik.v1i1.32627

Atmaja, I.M.D. (2014). Ethnomatematika pencipta lagu dan kaitannya dengan materi pembelajaran matematika. *Jurnal Santiaji Pendidikan*, *4(1)*. 1-12. https://bit.ly/3W1NrXQ

Belleza, K.E., & Loquias, C.M. (2015). Conceptualizing minuet in g major through mathematics and the generalized interval system. *Global Journal of Pure and Applied Mathematics*, *11*(6), 4413–4445. https://bit.ly/401jatf

Budi, J. (2020). Ethnomathematics : konsep matematika dalam pembuatan dan penggunaan klakat. *Prisma: Prosiding Seminar Nasional Matematika*, *1(1)*, 252–257. https://journal.unnes.ac.id/sju/prisma/article/view/37558/15475

Christianto, J. (2016). *Aritmatika modulo pada validasi nomor isbn*. Sekolah Teknik Elektro dan Informatika Institusi Teknologi Bandung. https://bit.ly/4a2ttlB

Lubis, A.M., Jusuf, S., Butar-butar, T.M., Malau, M. (1985). *Kalender peramalan batak*. Sumatera Utara: Departemen Pendidikan dan Kebudayaan Proyek Pengembangan Permuseuman. https://shorturl.at/yHajo

Fathiyah, H. (2022). *Penerapan teori bilangan pada permainan tebak umur ala hyakugo gen*. Sekolah Teknik Elektro dan Informatika Institusi Teknologi Bandung. https://bit.ly/4j1sh6c

Fauzi, L.M. (2022). *Buku ajar etnomatematika*. Jawa Barat: CV. Jejak.

Frifana, S.O. (2022). Implementasi kalender batak (parhalaan) pada adat batak. *Jurnal Elfalaky*, *6*(1), 137–158. https://doi.org/10.24252/ifk.v6i1.27182

Gultom, I. (2010). *Agama malim di tanah batak*. Jakarta: Bumi Aksara.

Insani, K., Syahminan, M., & Jailani, M. (2021). Marari sabtu dalam ugamo malim pada komunitas parmalim di kota medan. *Studia Sosia Religia*, *4(2)*, 1–11. http://doi.org/10.51900/ssr.v4i2.11061

Lukman, Bahri, S., & Irwansyah. (2018). Penerapan aritmatika modulo untuk menguji validitas dan mengembangkan nomor isbn /international standard book number (studi kasus: dinas perpustakaan dan kearsipan provinsi nusa tenggara barat). *Eigen Mathematics Journal*, *1(2)*, 1–7.

Mulyadi, M., Nursuprianah, I., & Raharjo, H. (2021). Penerapan aritmatika modulo pada transposisi akord berbasis web. *Nurjati Journal of Mathematics and Mathematical Science, 1*(1), 29-47.

Murdiyanto, E. (2020). *Metode penelitian kualitatif*. Yogyakarta: Lembaga Penelitian dan Pengabdian Pada Masyarakat UPN "Veteran" Yogyakarta Press.

Nurdiansah, M.A., & Artamefina, A. (2023). Penerapan penanggalan jawa dalam penentuan hari awal bercocok tanam di desa ngrangin kabupaten malang. *An-Natiq Jurnal Kajian Islam Interdisipliner*, *3(1)*, 8–15. https://doi.org/10.33474/an-natiq.v3i1.19132

Rahma, A.N., Rachmawati, & Zukhrianto. (2020). Aplikasi sistem modulo 7 dalam prediksi peringatan hari besar nasional indonesia tahun 2030. *MAP Journal*, *2(2)*, 1–8. https://doi.org/10.15548/map.v2i2.2260

Rahma, N.A., & Zukrianto. (2021). Prediksi 1 ramadhan tahun 1445-1460 h dengan aplikasi. *Lebesgue : JurnalIlmiahPendidikan Matematika, Matematika Dan Statistika*, *2*(1), 96–111. https://doi.org/10.46306/lb.v2i1.49

Rofifah, D. (2020). Teori aritmatika modulo. In *paper knowledge toward a media history of documents*.

Septia, T., Nuraini, A., & Wahyu, R. (2024). Eksplorasi etnomatematika pada aktivitas masyarakat petani di kecamatan gondanglegi kabupaten malang pendahuluan. *Jurnal Inovasi Pembelajaran Matematika: PowerMathEdu (PME)*, *3*(2), 253–262. https://doi.org/10.31980/pme.v3i2.1702

Sihombing, D.I., & Simanjuntak, R. (2020). Etnomatematika dalam transposisi akord ende mandideng [Prosiding seminar ethnomatematics]. Universitas HKBP Nommensen.

Tambunan, R. (2023). Kepercayaan parmalim dalam relasi agama dan budaya. *De Cive: Jurnal Penelitian Pendidikan Pancasila Dan Kewarganegaraan*, *3*(12), 437–442. https://doi.org/10.56393/decive.v3i12.2059

Utami, N.W., & Sayuti, S.A. (2020). An ethnomathematics study of the days on the Javanese calendar for learning mathematics in elementary school. *Ilkogretim Online*, *19*(3), 1295–1305. https://doi.org/10.17051/ilkonline.2020.728063

Weaver, A. (2012). *Arithmetic: a textbook for math 01 3rd edition (2012)*. New York: Department of Mathematics and Computer Science.

Yuli, T., & Siswono, E. (2020). *Inovasi pembelajatan matematika di era revolusi industri 4.0* [prosiding mahasaraswati seminar nasional pendidikan matematika]. Universitas Mahasaraswati, Denpasar, Indonesia.

https://e-journal.unmas.ac.id/index.php/Prosemnaspmatematika/article/view/889

Yuniawatika. (2015). *Penerapan artimatika modulo dalam budaya primbon Jawa* [Prosiding seminar nasional matematika dan pendidikan matematika]. UNESA, Surabaya, Indonesia. https://bit.ly/4gTkq8A