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Prayitno, S., Hayati, L., Novitasari, D., & Lu'luilmaknun, U. (2026). Wariga Ethnomathematics: Mathematical Structures and Sasak Cultural Values in the Traditional Calendar System. *Foro de Educación*, 24(1), 320-340. doi: https://doi.org/10.14201/fde.24116

# *Wariga Ethnomathematics: Mathematical Structures and Sasak Cultural Values in the Traditional Calendar System*

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Recibido / Received: 02/12/2025
Aceptado / Accepted: 12/03/2026

**Abstract:** Mathematics is considered difficult for some students because it tends to be irrelevant to everyday life practices or culture. This study aims to investigate the mathematical structures inherent in the *Wariga* system and identify its unique characteristics as a form of cultural mathematics to serve as a recommendation for its utilization in mathematics education. The research employed an ethnographic design within an ethnomathematics framework. The primary data collection instruments consisted of field notes, structured interview guides, and documentation studies. The key participants included three groups: a young *Wariga* educator and maestro, two Bayan officials and traditional leaders, and a community member. Data were analyzed using qualitative techniques, including data reduction, data display, and conclusion drawing and verification. The findings revealed that the *Wariga* incorporates several mathematical structures and concepts, such as modular arithmetic (modulo 7), a mapping system (*naptun*), and nested cycles (*windon*). It combines mathematical, astronomical, and cosmological principles to determine auspicious days for activities like rice planting, weddings, and traditional ceremonies. The study concludes that mathematics has naturally emerged and developed within the Bayan community as a tradition sustained through the *Wariga*. These findings recommend the integration of *Wariga* into contextual mathematics learning to foster computational thinking and suggest the development of digital software to simulate its calculations.

**Keywords:** Computational Thinking, Indigenous Mathematics, *Sasak* Culture, Traditional Calendar.

## 1. Introduction

Mathematics possesses a rich and extensive historical background (Gray, 2023). In practice, it extends beyond the abstract formulas found in textbooks; it also exists and develops within societies as an inherent cultural tool (Khairunnisa et al., 2025; Listiyani et al., 2025; Pakabu et al., 2024; Rurisman, Yerizon & Tasman, 2023). The field that specifically examines the intersection of mathematics and culture is known as ethnomathematics (Bantaika et al., 2025; Rodríguez-Nieto et al., 2025; Sudirman, Rodríguez-Nieto & Bonyah, 2024; Sugianto et al., 2019), which focuses on how cultural groups identify, conceptualize, and apply mathematical ideas in their daily lives (Darakay, Ayal & Mananggel, 2025). This is frequently observed in activities such as crafting, farming, constructing traditional houses, and determining the timing of ceremonies (Pathuddin & Mariani, 2023; Pratama, Mardiyana & Saputro, 2019; Umbara, Prabawanto & Anwar, 2025).

A growing body of research reveals that distinct cultures exhibit unique modes of mathematical thinking (Borromeo Ferri, 2015; Danoebroto, 2024). This evidence challenges the notion that mathematics is solely the domain of Western societies and underscores its independent development across the globe (Owens, 2014; Rosa et al., 2022). A compelling illustration of this is found in the various traditional calendar systems developed by indigenous communities (Kusuma, Hanum & Abadi, 2025). For instance, the Maya civilization created a highly complex calendar capable of projecting time thousands of years into the future (Yurchenko, 2019). Similarly, Aboriginal Australians have long observed celestial bodies and environmental changes to define seasonal patterns (Hamacher et al., 2019), while Hindus employ the astronomical *Panchang* system to ascertain auspicious days (Venkateswaran, 2019). The Chinese, meanwhile, integrate solar and lunar cycles within a lunisolar calendar (Randau & Medinskaya, 2015). These diverse calendrical systems demonstrate that traditional societies possessed sophisticated mathematical abilities, albeit expressed through methods that often differ from contemporary formal mathematics (Maravelia, 2017).

Similar to other world calendars, within the Indonesian context, while substantial research is conducted on the calendars of major cultures, there remains a significant gap in the study of systems from smaller regions, such as the island of Lombok (Kusuma et al., 2025). Previous studies have effectively explored other Indonesian calendars. For example, Niken Wahyu, Suminto and Jailani (2023) investigated the Javanese calendar, uncovering the application of remainder concepts and modulo operations, and noted its potential for educational enrichment. Likewise, Kusuma et al. (2025) and Syahrin, Turmudi and Puspita (2016) analyzed the *Javanese Aboge* calendar, revealing its use of advanced concepts like modular arithmetic and the *Chinese Remainder Theorem*.

*If* $x \equiv a_1 \ (mod\ m_1)$, $x \equiv a_2 \ (mod\ m_2)$, … $x \equiv a_k \ (mod\ m_k)$ with $m_1, m_2, \ldots, m_k$ being two-to-two prime, then there is one unique solution modulo $M = m_1 m_2 \cdots m_k$ (Ďuriš, Bojdová & Šumný, 2022; Li, Xia & Liang, 2010).

In contrast to these studies, this research focuses on a lesser-known calendar system from Lombok, the *Wariga. Wariga* is chosen because it is a traditional calendar central to the Sasak people, particularly in the Bayan area of North Lombok. The Bayan community is a community that strictly maintains its culture by preserving traditions passed down from generation to generation, including the *Wariga* calendar system. It is used to determine auspicious days for critical activities such as rice planting, weddings, and traditional ceremonies through a unique system of assigning and calculating numerical values to years, months, and days (Awaludin, 2019; Damayanti & Sulastri, 2021; Dwi Wiratmaja et al., 2025).

Furthermore, uncovering the mathematics embedded in the *Wariga* could provide rich, contextual material to enhance the quality and engagement of mathematics instruction, making it more relevant to students' cultural contexts. A comprehensive literature search conducted on Scopus reveals that no studies have examined the *Wariga* in depth, particularly from a mathematical perspective. Consequently, the sophistication of the mathematical calculations underlying this calendar system remains largely unknown and undocumented. This research aims to address this gap by preserving the mathematical knowledge embedded in the *Wariga* as a crucial effort to safeguard this local wisdom. Furthermore, the study seeks to explore how the *Wariga* can be utilized to optimize the quality of mathematics instruction, thereby making it more contextual and engaging for students. The results of this research are then expected to have an impact on the development of ethnomathematics theory and mathematics learning. Based on this rationale, the present study has three primary objectives: to identify the mathematical structures and concepts inherent in the *Wariga* system, to analyze the unique characteristics of cultural mathematics within the *Wariga*, and to propose its application as a contextual alternative for mathematics learning. To guide this investigation, the following research questions (RQs) are formulated:

**RQ1:** What mathematical concepts and operational formulas govern the *Wariga* calendar system?

**RQ2:** What are the defining characteristics of the cultural mathematics found in the *Wariga*?

**RQ3:** How can the *Wariga* calendar system be effectively integrated into mathematics learning strategies?

## 2. Method

### *2.1. Research Design*

This study employed a qualitative research approach utilizing an ethnographic design. This methodology was selected due to its unique capacity to facilitate an in-depth and contextual understanding of cultural characteristics from the emic perspective of community members themselves (D'Ambrosio, 1985, 1999; Dominikus, Madu & Bale, 2025; Pathuddin & Nawawi, 2021; Sabaruddin et al., 2022; Shannon, 2021). Furthermore, ethnography is particularly well-suited for investigating the mathematical ideas, concepts, and practices inherent within a specific cultural group.

These characteristics were directly relevant to the objectives of this research, which sought to identify and describe the mathematical structures of the *Wariga* and analyze the features of its cultural mathematics for potential application in educational contexts. The research procedure was guided by an established ethnomathematics research framework (Kholid & Husodo, 2025; Nasrum, Salido & Chairuddin, 2025; Nurjanah, Mardia & Turmudi, 2021). This framework provides a structured approach beginning with four general questions that guide the investigation and aid in addressing the specific research questions (Prahmana & D'Ambrosio, 2020; Prahmana et al., 2021). A detailed outline of the research stages, aligned with this framework, is presented in Table 1.

Table 1: Ethnographic Research Design.

| General Questions | Initial Answers | Starting Point | Specific Activity |
|---|---|---|---|
| *Where to start looking?* | In the activity of determining auspicious days for determining planting times, traditional processions, and other important activities, Wariga uses practices that contain mathematics. | Culture | In-depth interviews with people who understand Sasak culture or traditional figures who use *Wariga* in determining auspicious days. |
| *How to look?* | Investigating aspects of activities related to determining auspicious days for planting, traditional processions, and other important activities using *Wariga* that are related to mathematical concepts. | Knowledge systems, technologies, and alternative ways of thinking. | Identifying mathematical ideas and concepts contained in these activities. |
| *What it is?* | Evidence of alternative thought processes used by *Wariga.* | Philosophy of mathematics | Uncovering mathematical characteristics in activities such as determining auspicious days for planting, traditional processions, and other important activities based on *Wariga.* |
| *What it means?* | Valued important for culture and important value patterns for mathematics. | Anthropologist | Describing the relationship between mathematical knowledge systems and the cultural context of the Sasak people in Bayan. |

## *2.2. Sample and Data Collection*

Data collection for this study employed a multi-faceted approach, comprising a literature review, field observations, documentation studies, and in-depth interviews with key participants. The in-depth interviews were conducted using a semi-structured interview guide to ensure both focus and flexibility. The interview questions consisted of 29 open-ended questions related to aspects of language, knowledge systems, social systems, technology, economics, religion, and the arts. In addition, there were also several additional open-ended questions related to mathematics learning. Some examples of interview questions were "*Is there a special calendar or time calculation system?" "How has the concept of time influenced the process of daily spiritual activities or the division of time or days in the Telu time system still used today?"* Participant selection was carried out through purposive sampling. To ensure data authenticity and credibility, three specific ethnographic criteria were applied to identify suitable participants. Individuals were selected based on the following: administrative and actual residency in Bayan, daily use of the Bayan language or dialect, and a historical background of having lived and grown up in the Bayan community. These criteria were implemented to guarantee that the participants possessed the deep cultural immersion necessary to provide authoritative insights into the Wariga system.

Based on these criteria, three groups of participants were selected. The first was a young *Wariga* educator and maestro from Bayan, Indonesia. This participant served as a key informant for exploring the determination of auspicious days and times for planting and traditional ceremonies. The second group comprised two Bayan officials and traditional leaders. They provided data regarding the origins, purpose, and historical use of *Wariga*. The third participant was a community member who regularly applies traditional practices in daily life and uses the *Wariga* to determine auspicious days for ceremonies. In-depth interviews were conducted from July 9, 2025, to August 30, 2025. Four interviews were conducted; each lasted approximately 120 minutes. Transcripts of the interviews could be accessed on the following page: participant interview results.

The documentation used in this study included photographs and videos taken during interviews, photographs of related artifacts, and Wariga manuscripts. All research instruments met the requirements for validity and reliability estimation. Validity was verified by seeking constructive advice from experts regarding the instruments. The researcher's position in this ethnographic research context was that of an outsider who did not originate from the Bayan community. This study also complied with ethical research principles by ensuring that all informants provided information voluntarily and in accordance with the informant's prior informed consent, did not disclose detailed information about the informant, and ensured that the data presented was data that had been authorized for publication.

### *2.3. Analyzing of Data*

The data were analyzed using a qualitative approach. This process consisted of three stages: data reduction, data display, and conclusion drawing/verification (Isnawan, Alsulami & Sudirman, 2024; Miles, Huberman & Saldana, 2014; Sridana et al., 2025; Sukarma, Isnawan & Alsulami, 2024). During the data reduction phase, the researchers selected and focused on observation and interview data that specifically revealed mathematical concepts within *Wariga* (addressing RQ1), identified its unique mathematical characteristics (RQ2), and highlighted aspects applicable to mathematics learning (RQ3). For the data display phase, the researchers created conceptual maps to illustrate the relationship between the *Wariga* calculation system and mathematical concepts (RQ1), charted the unique characteristics of *Wariga* mathematics (RQ2), and mapped *Wariga* concepts onto school mathematics topics alongside potential pedagogical approaches (RQ3). In the conclusion drawing/verification phase, the researchers identified specific mathematical formulas used in *Wariga* and verified them with *Wariga* experts (RQ1). The mathematical uniqueness of *Wariga* was established through validation with mathematics and cultural experts (RQ2). Finally, a model for integrating *Wariga* into the mathematics curriculum was developed (RQ3).

## 3. Results and Discussion

### *3.1. Results*

**RQ1: What mathematical concepts and operational formulas govern the *Wariga* calendar system?**

The Bayan community continues to uphold its customs and religious laws. This is evident in the numerous traditional houses that are passed down through generations. Figure 1 depicts a Bayan traditional house that is preserved to this day. Besides serving as a residence, the Bayan traditional house has served as the center of religious and customary activities for the Sasak people of Bayan. It also has served as a symbol of identity that the Bayan people have preserved their culture from generation to generation and as proof that values and traditions have been closely guarded from generation to generation.

Visually, the *Wariga* calendar appears to contain mathematical concepts or formulas. It features a flat surface comprising multiple squares, each containing a varying number of small circles (Figure 2). In their daily lives, the Bayan people use the *Sareat Adat Bayan* calendar. This system integrates three distinct calendars: the *Hijri* calendar, the traditional *Bayan Sareat Adat* date, and the *Gregorian* calendar (Figure 3). This integration allows the community to use the calendar for a wide range of purposes. Excerpts from interviews between researchers and informants could be seen in Table 2. Table 2 provided information that Wariga was used to determine auspicious days, particularly for traditional ceremonies. Even religious ceremonies were conducted according to Wariga calculations. However, the consequence was that these activities were held twice, following government regulations as the primary consideration for religious events.

Figure 1: Bayan Traditional House.

Figure 2: Wariga Board.

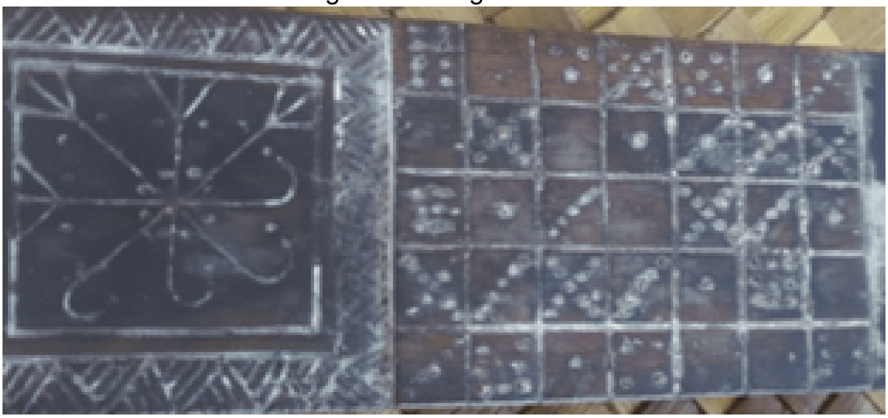


Figure 3: Bayan Traditional Sareat Calendar.


Based on the results of the data analysis, it was found that several basic mathematical concepts were applied in the *Wariga* calendar system. First, there was a symbolic number system *(naptun).* Each element of time, such as year, month, and day, was assigned a specific numerical value called naptun. The *naptun* possessed a dual function: it expressed a value quantitatively and also had a specific qualitative designation. For example, the year *Alip* was assigned the value 1, *Ehe* was 5, and *Jim Awal* was 3. Second, the system utilized modular arithmetic operations. The *Wariga* calendar included calculations that used the modulo 7 operation to determine the day. The basic formula that was used is $H \equiv Ton[y] + Ulan[m] + t - 2 (mod 7)$ where $y$ represented the traditional year, $m$ represented the month, and $t$ represented the date (ranging from 1 to 29 or 30). The third identified concept was a periodic cycle system, which comprised weekly (7-day), monthly (12-lunar month), *winduan* (8-year), and *wuku* (30-week) cycles.

Table 2: Excerpt from the Results of the Researcher's Interview with the Informant.

| Researcher Questions | Informant Answers |
|---|---|
| *"Is there a special calendar or time calculation system?"* | *"We call it Wariga, right? The people use the Hijri calendar; the local calendar is used. We have already called it that, right? For example, we call it Wariga. Yes, this is common in Lombok, right? There are only those who call it "Wariga," some call it "Wariga," some call it "Uriga," and some call it "Uriga," so the Sasak have that, but it's actually the same, so the question is, calculating auspicious days means, is there a certain number that is considered sacred? There are these numbers, right? Oh, there is the number 8, yes, but the 9th one? Wow, there is also one, but if this one isn't there, yes, 89 isn't there until 7. Yes, until 7. If this one is a secret, why is that? And that's usually in the study of one person. And that's usually in the study of those people, how many times the activity in the ceremony is carried out, for example, like reading prayers. Maybe, well, if that's every ritual, every time, this is how many times one activity in the ceremony is carried out; for example, burning incense continuously and hacking, whatever, that's every ritual, every ritual, that incense is mandatory, we don't have that ritual, right? Nyippin Nyongkolan and "So you can't be like that employee, Muharram Safar, so you can't then the month of Ramadan, oh Ramadan."* |
| *"Who is the traditional or spiritual figure who leads the calculation of time or planning of the ceremony?"* | *"Is it the traditional figure who leads? Am I actually a traditional activist? Yes, if I am truly a person, I have to be from the lineage. Yes, because the title of the figure comes from someone else's lineage. If someone learns something like this, it doesn't have to be from the lineage, but the one who leads the traditional ceremony is the traditional official. We have traditional officials, there are robbers, there are Kiai, there are creatures, but usually the one who leads the traditional journey is the provider who is responsible. If it is the Kiai, it will be him. The story is that this is a worldly matter, this is a matter of the afterlife, the provider is a customary matter, and this is a religious matter."* |

The main calculation formulas employed in the *Wariga* analysis included the year determination formula, the day calculation, and the day sequence system. The day calculation formula that was used is as described previously. The year calculation formula that was applied was:

$$Day\ 1\ of\ Muharram = Year\ Name = Year\ Naptun$$

*Year's Journey = Day 1 of Muharram (Year Naptu Tahun) + Value of the First Month Visible by the Star Rowot (Kemukus)*

The day order system that was employed was as follows:

*OrderJ = [Friday (0), Saturday (1), Sunday (2), Monday (3), Tuesday (4), Ednesday (5), Thursday (6)]*

The *naptun* tables that were used in the analysis are presented in Table 3 (for the *naptun* year within the *8-year windon* cycle) and Table 4 (for the *naptun* month).

Table 3: Wariga Sasak Bayan Calendar Windon System.

| Year | Name | *Naptun Ton* |
|---|---|---|
| 1 | *Alip* | 1 |
| 2 | *Ehe* | 5 |
| 3 | *Jim Awal* | 3 |
| 4 | *Se* | 7 |
| 5 | *Dal* | 4 |
| 6 | *Be* | 2 |
| 7 | *Wau* | 6 |
| 8 | *Jim Akhir* | 3 |

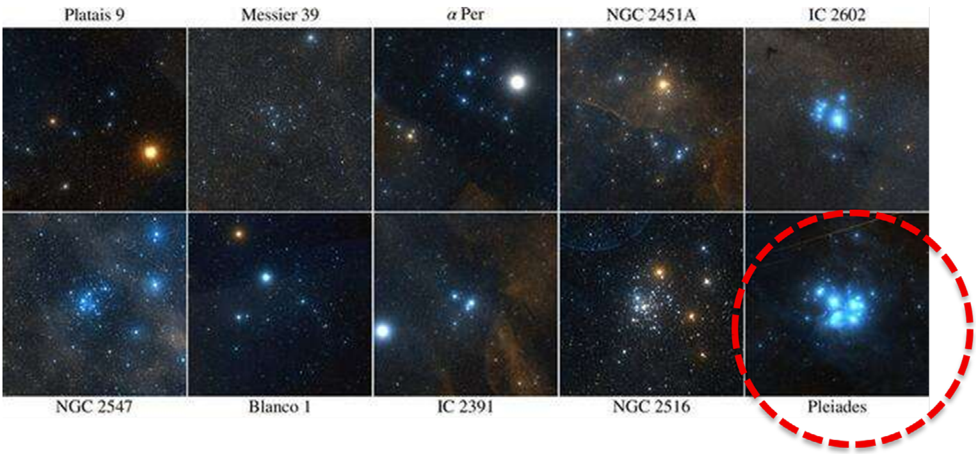
Table 4: Naptun Ulan calendar Wariga Sasak Bayan.

| *Ulan* | Month Name | *Naptun Ulan* |
|---|---|---|
| 1 | *Muharram* | 7 |
| 2 | *Syafar* | 2 |
| 3 | *Rabiul Awal* | 3 |
| 4 | *Rabiul Akhir* | 5 |
| 5 | *Jumadil Awal* | 6 |
| 6 | *Jumadil Akhir* | 1 |
| 7 | *Rajab* | 2 |
| 8 | *Sya'ban* | 4 |
| 9 | *Ramadhan* | 5 |
| 10 | *Syawal* | 7 |
| 11 | *Dzulkaidah* | 1 |
| 12 | *Dzulhaji* | 3 |

### RQ2: What are the defining characteristics of the cultural mathematics found in the *Wariga*?

There were several unique characteristics of cultural mathematics in the *Wariga* calendar system. First, *Wariga* integrated astronomy and mathematics in its calculations. As evidence, observations of the *Rowot* star *(Pleiades)* served as the basis for calculations; the synchronization of three calendar systems, namely *Rowot, Hijri*, and *Gregorian*; and the determination of seasons was based on astronomical phenomena. The P*leiades* has been a star cluster that has looked like a collection of small stars close together in the night sky. It is an open star cluster in the constellation *Taurus.* It has also been referred to as the *Seven Sisters* (Chulkov, Strakhov & Safonov, 2025). Second, the cosmological-mathematical dimension was used in *Wariga*. In *Wariga,* the term *"diwasa"* was known, which meant ten natural elements consisting of *kembang* (flower), *gunung (mount), ulan* (moon), *liat, serengene, banyu* (sea), *geni, gumi* (earth), *angin* (wind), and *becik.* Each of these elements was believed to have had a symbolic meaning that signified good luck. This combination was the basis for the Bayan people in determining auspicious days and times when calculating with *Wariga.* Figure 4 shows the shape of the robot star and its comparison with other stars.

Figure 4: Rowot Star (Meingast, Alves & Rottensteiner, 2021).



Third was the *wuku* and *engkel* system. *Wuku* meant 30 weekly cycles with certain characteristics. While *engkel* meant 6 rotating natural elements, namely *jelma, sato, iwak, manuk, uku,* and *gogong.* There was a hierarchical structure in *Wariga*, namely year, month, *wuku*, week, and day. Fourth, *Wariga* was used for various purposes, such as determining traditional and religious rituals, providing agricultural and planting season guidance, and choosing auspicious days for weddings or building houses. Fifth, the traditional calculation medium used was the *Wariga* board made of wood, which functioned as a traditional calculator; its system was transcribed into a modern writing format, and the calculation method was preserved from generation to generation.

Unlike other traditional or modern calendars, *Wariga* was not merely a chronological time marker but also formed a cultural knowledge system that integrated various aspects, such as astronomy, mathematics, cosmology, and symbolic value. The Hijri or Javanese calendar typically focused on lunar–solar combinations for religious or social purposes. The modern Gregorian calendar emphasized administrative functions with accurate astronomical aspects. *Wariga*, however, transcended these calendars by using observations of the *Rowot (Pleiades)* star as the basis for calculations, harmonizing three calendar systems simultaneously. It also integrated the concepts of *diwasa* and *engkel,* which were rich in symbolic meaning, in determining auspicious days. Wariga had a hierarchical structure, consisting of years, months, *wuku,* weeks, and days. It also utilized a *Wariga* board as a traditional counting medium. This made Wariga not merely technical but also cultural and pedagogical. In other words, *Wariga* represented the calendar as a tool for making holistic life decisions.

### RQ3: How can the *Wariga* calendar system be effectively integrated into mathematics learning strategies?

There were several ways to utilize *Wariga* in mathematics learning. First, *Wariga* was used as a source of inspiration in mathematics learning. *Wariga* could be used as a link between abstract mathematical concepts and real-life cultural contexts or practices in society. It could also provide social meaning to mathematical operations and increase learning motivation through cultural relevance. In addition to inspiring contextual learning, *Wariga* also demonstrated several ethnomathematic concepts by strengthening the justification that mathematics grew within the cultural practices of communities in everyday life, becoming an alternative learning method based on local wisdom, and serving as an appreciation for indigenous mathematics.

Second, there was the application of mathematical concepts in *Wariga. Wariga* calculations helped students learn various mathematical concepts, such as number theory, algebra, and geometry. For example, *naptun* calculations trained students' abilities in arithmetic operations, such as modular arithmetic; the concept of remainders in division; and integer operations and mappings. In algebra, *Wariga* helped students learn systems of linear equations using *Wariga* formulas, functions and mappings between domains and codomains, and the structure of cyclic groups in time cycles. As for geometric concepts, the cyclical patterns in *Wariga* represented the geometry of circles, the concepts of period and rotation, and the visualization of calendar data.

Third, mathematical skills were developed, such as problem-solving and computational thinking. Problem-solving skills were trained through systematic algorithms in *Wariga* that were used to determine auspicious days, logical thinking in step-by-step calculations, and decision-making based on mathematical results. Computational thinking was developed through the decomposition of problems involving years, months, and days; pattern recognition in time cycles; abstraction of the concept of time into numbers; and algorithm design for calendar calculations.

The fourth form of utilization was integration between disciplines. For example, *Wariga* integrated mathematics and culture. Mathematics was used as a tool that played a role in social life, cultural mathematics served as a bridging concept, and it fostered an appreciation of diversity in mathematical approaches. Another example was mathematics and science. *Wariga* taught that mathematical calculations took into account astronomical aspects, such as star observations in determining auspicious days, as well as the use of mathematics in agriculture and ecology, such as for determining planting and harvesting times.

The fifth benefit of *Wariga* was its integration into innovative learning models or approaches, such as problem-based learning, collaborative learning, and technology integration. For example, *Wariga* could be used as a tool to complete case studies on traditional holiday calculations and project-based calculations for planning important community ceremonies. In the context of collaborative learning, *Wariga* could be used as a topic for cross-cultural discussions on calendar systems, comparisons with international calendars, and peer learning in algorithmic calculations. Technology integration could have included the development of *Wariga* algorithm programs, mobile applications for automatic *Wariga* calendar calculations, and data visualization for calendar charts.

In general, the *Wariga* calendar system used by the Sasak people of Bayan represented a rich cultural mathematics. *Wariga* demonstrated that modern mathematical concepts, such as modular arithmetic, systematic algorithms, and periodic functions, had long been practiced in Bayan society. *Wariga's* unique characteristic lay in the integration of cosmological, astronomical, and socio-cultural dimensions within a coherent mathematical framework. The Wariga calendar then offered an ethnomathematics approach that was expected to optimize the meaning and relevance of mathematics to cultural life, problem-solving and computational thinking abilities, and recognized that mathematics was not the only perspective but was also influenced by culture and had different forms of mathematical knowledge depending on different environments or cultures. The findings of this study then proved that mathematics was not separate from life but rather grew and developed within cultural practices that existed in the midst of society.

## 4. Discussion

Based on the research results, it is discovered that the *Wariga* calendar system used by the Bayan people serves not only as a simple time marker but also as a source of authentic local knowledge. This knowledge is coherent and complex, incorporating various mathematical calculations, astronomical observations, and cosmological philosophies that form a unified whole. There are at least several unique and interesting findings from this research. First, the research confirms that the Sasak community in Bayan has developed a sophisticated mathematical system for determining time. *Naptun* represents the use of a symbolic number system, a fundamental concept in mathematics. *Naptun* demonstrates that the Bayan people already possess an abstract understanding of quantification. This system maps qualitative names (alip, ehe) to quantitative values (1, 5). This serves as a reminder that numbers have multiple meanings (Kilic, 2018; Nussupbekova et al., 2022). For example, in the early number systems of certain cultures, numbers have both computational and symbolic meaning (Mukhametkaliyeva et al., 2022; Ngullie & Khyriem, 2024; Yarmarkina, 2022). This multiple meaning is a unique characteristic of ethnomathematics, which interprets numbers as having infinite meaning (Bertolini, 2017; Nussupbekova et al., 2022).

Second, the explicit application of modular arithmetic, specifically modulo 7, is the most striking finding in this study. The formula $H \equiv Ton[y] + Ulan[m] + t - 2 (mod 7)$ is an algorithm used by the Bayan people to determine the day. This formula pre-computes constants, namely the year and month, to simplify complex cyclical problems into a simple series of additions. These findings then position mathematical thinking in the *Wariga* calendar system, with the concept of modulo 7, as equivalent to the principles underlying well-known algorithms, such as *Zeller's* congruence in the *Gregorian* calendar (Karjanto & Beauducel, 2024; Kusuma et al., 2025). The history of mathematics taught in schools is often dominated by the achievements of major civilizations, such as Greece, Europe, India, and Arabia. However, much of the history of mathematics originates from other world civilizations (Chacón-Díaz, 2022; Oliveira, 2024). These research findings add to the existence of a new culture from the east, namely Indonesia, represented by the Sasak people of Bayan through the *Wariga* calendar system.

Third, the structure of the *Wariga* calculation system is built on several nested cycles. For example, a 7-day week, a 12-month lunar year, an 8-year *windon*, and a 210-day *wuku* cycle. These findings indicate that the Bayan people possess an intuitive understanding of the concepts of periodicity, cyclic groups, and least common multiples. Periodicity is the property of a function, sequence, or phenomenon that repeats itself regularly over a specific period or time interval (Silva et al., 2021). A cyclic group is a group generated by a single element. This element is called the group generator. The group of integers modulo n is an example (Muktyas et al., 2023; Wen, 2022). The *windon* cycle (8 years), with its specific sequence of values, namely (1, 5, 3, 7, 4, 2, 6, 3), is not chosen arbitrarily but is a carefully constructed sequence using specific rules. This cycle is likely constructed in an effort to ensure the calendar's long-term functionality.

Fourth, the *Wariga* calendar system is unique because it combines mathematical concepts with other aspects of life, such as cosmology and astronomy. There are several reasons for this finding. Astronomically, the calendar is established based on observing the rising of the *Rowot Star (Pleiades),* a calculation practice also widely used in other regions and cultures (Sodnompilova, 2024; Varisco, 2022). This finding indicates that the *Wariga* calendar uses a scientific (empirical) method by determining time through predictable celestial events. The *Wariga* system also synchronizes three components of life: ritual (human), celestial (stars, moon, and sun), and agriculture (seasons) to create an integrated ecological calendar system. This finding aligns with several previous studies that reveal that utilizing a calendar based on celestial observations and ethnomathematical knowledge can guide communities in carrying out agricultural and cultural activities to ensure sustainability and food security based on environmental changes (Hastuti & Hafidh, 2025; Kusaeri et al., 2025).

The combination of the ten elements *(diwasa)* and the six rotating elements *(engkel)* strengthens the symbolic and qualitative layers of mathematics in *Wariga.* In other words, the numerical output of a calculation is not only a quantitative result but also a qualitative interpretation with various meanings, such as fortune or good fortune. This finding represents a mathematical mapping with a time domain symbolized quantitatively, with a codomain symbolized as a series of meanings steeped in cultural and spiritual values. This finding demonstrates a fundamental principle of ethnomathematics, which reveals that mathematics is used as a tool to understand, model, and navigate both the physical and metaphysical worlds, typically employed to interpret cultural, spiritual, and natural aspects (Becik et al., 2022; Suherman & Vidákovich, 2022). These findings indicate that the Bayan people have indirectly, consciously, or unconsciously used mathematics as a tool to maintain and preserve their culture from generation to generation.

Fifth, *Wariga* has the potential to be utilized in mathematics learning as a pedagogical force. *Wariga* serves as a tool to teach contextual mathematics to students. It functions as a bridge to connect abstract mathematical concepts, making them more accessible, understandable, and meaningful. For example, the concept of modulo is often considered irrelevant and abstract by some students. However, the presence of *Wariga* provides a contextual example of this concept. Students can be asked to calculate *naptun* and experience the effect of rotating back to modulo 7 when the number exceeds 7. In addition, students also understand the practical benefits of modulo 7. This finding is in line with various pedagogical theories and previous research findings that reveal mathematics learning should begin in the context of everyday life to be more meaningful for students (Andzin et al., 2024; Bravo et al., 2025; Isnawan & Almazroei, 2023; Kardoyo et al., 2020; Maskur et al., 2020; Sari et al., 2023).

*Wariga* also fosters higher-order thinking skills. The step-by-step algorithms used in *Wariga* serve as models that can be used as examples to facilitate students' computational thinking. Computational thinking is a systematic and logical way of thinking in solving problems by breaking down complex problems into smaller parts, recognizing patterns, filtering important information, and formulating clear solution steps (Jyrwa, Jayaraman & Joseph, 2025; Saig & Hershkovitz, 2024). Students are expected to deconstruct problems by decomposing years, months, and days; recognize patterns by identifying patterns in the *wuku* and *windon* cycles; abstract time into numerical values; and design algorithms by sequencing steps to find solutions (Wiese et al., 2024).

*Wariga* has become a pioneer in culturally responsive learning and facilitates an interdisciplinary framework in mathematics learning (STEAM) (El Bedewy & Zsolt, 2023). *Wariga* teaches that mathematics is knowledge derived from students' own cultures, passed down from generation to generation, and not knowledge entirely derived from outside sources. *Wariga* can be used as a setting for creating project-based learning that requires multiple disciplines to complete. These disciplines incambrosioude history or culture, mathematics, and astronomy. In fact, the use of technology, such as the creation of the *Wariga* calculator, can also be an object of study in other projects.

In the era of artificial intelligence (AI), *Wariga* remains relevant. In fact, *Wariga's* position is increasingly strong as a bridge between mathematics, local wisdom, and culture. AI helps visualize, model, and explore mathematical and astronomical patterns in a more systematic manner. In other words, AI enhances *Wariga* knowledge. For example, AI is used to conduct simulations, process data, and create *Wariga* (digital) calculator applications. AI integration also becomes an object of study that encourages students to think critically about how traditional knowledge is interpreted into modern computing systems. This activity makes mathematics more understandable, not merely as a transformation of abstract concepts, but also as knowledge born from culture or society itself, passed down from generation to generation while maintaining that heritage and having meaning in light of current technological developments.

The findings of this research also are expected to contribute to efforts to maintain *Wariga's* existence amid the era of modernization and strengthen Sasak cultural identity in academic and formal educational contexts. This finding also has the potential to empower the Bayan community as a contextual learning resource for students, develop a curriculum based on culture or local wisdom, and inspire wiser decision-making in the social and agricultural sectors. The integration of *Wariga* in learning, then, is expected to strengthen cultural literacy for the younger generation, develop educational tourism, strengthen local capacity, and provide cultural education that impacts not only the social aspect but also the economic aspect of the community. The findings of this study also broaden the insight that mathematics is not only about formal and universal concepts but also is knowledge that is built or is born through interactions between society and its environment, including interactions with the universe. The existence of *Wariga t*hen becomes a bridge that connects abstract mathematical concepts so that they are learned more easily by students through cultural, astronomical, and cosmological approaches.

## 5. Conclusion

Based on the previous description, all research findings are addressed, and several findings can be concluded. First, the Sasak people of Bayan develop a sophisticated mathematical system for determining time and interpreting it quantitatively and qualitatively, such as *naptun*. Second, the *Wariga* uses modular arithmetic formulas, such as modulo, to determine auspicious days. Third, the structure of the *Wariga* calculation system is constructed with numerous nested cycles, such as *windon.* Fourth, the *Wariga* calendar system is unique because it combines computational, cosmological, and astronomical concepts, thus tending to be categorized as an ecological calendar. Fifth, *Wariga* has the potential to be a contextual learning tool, particularly in teaching the concept of modulo. It is estimated to optimize computational thinking skills due to the systematic or algorithmic nature of the calculation process in *Wariga.*

Overall, this series of findings strengthens the justification that *Wariga* is a monumental Sasak cultural heritage in calendar science and is evidence that the Sasak people, particularly in the Bayan region, possess a history of natural mathematical knowledge. In other words, mathematics for the Sasak people of Bayan is a long-standing practice that exists and develops within the community. In fact, the integration of astronomy and cosmology into these calculations provides scientific evidence that their mathematical knowledge has reached a more advanced level. The Bayan community is able to construct its own ethnomathematics model, providing space for developing mathematics learning based on local wisdom. However, this integration requires several comparative studies to ensure that some calculation rules in the *Wariga* community that do not yet conform to modern mathematical principles are integrated proportionally into mathematics learning in schools.

### *5.1. Recommendations*

Based on the findings, several recommendations for further research can be made. First, future research focuses on developing and piloting based lesson plans for learning time measurement, number patterns, simple statistics, cycles, and geometry for various levels of education, including higher education. Second, a more in-depth study needs to be conducted to compare *Wariga* with other traditional Indonesian calendar systems, which would help identify patterns of similarities and differences. Third, digital software should be developed to simulate the *Wariga* calendar system, preserving the cultural knowledge and comprehensive integrations within this system. Fourth, comparative studies between *Wariga* and other traditional calendars or longitudinal studies on the transmission of *Wariga* knowledge are conducted.

### *5.2. Limitations*

This study faced several limitations during its implementation. First, the respondent pool was limited to traditional leaders, which restricted the total number of participants. Second, some questions on the research instrument were not fully answered by respondents, as certain information was withheld to maintain respectful relationships with the indigenous community. Third, the study focused on only one community, the Bayan tribe. Fourth, there were limitations in accessing more senior *Wariga* masters. Fifth, the generalizability of the research findings was limited due to several previous limitations.

### *5.3. Acknowledgements*

The researchers would like to thank all participants who helped in this research activity.

### *5.4. Conflict of Interest*

There is no conflict of interest in this research.

## 6. Funding Source

The research was funded by the Ministry of Higher Education, Science, and Technology with the master contract number 079/C3/DT.05.00/PL/2025 and the derivative contract number with the University of Mataram 4371/UN18.L1/PP/2025.

### *6.1. Generative AI statement*

The researcher did not use AI in the process of writing this article.

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