

The Ethnomathematics of the Otonan in the Balinese Calendar System

Gede Ngurah Oka Diputra¹

¹IKIP Saraswati, Indonesia

Anak Agung Purwa Antara²

²IKIP Saraswati, Indonesia

I Wayan Sudiarta³

³IKIP Saraswati, Indonesia

I Made Yasna⁴

⁴IKIP Saraswati, Indonesia

I Gede Bagus Wisnu Bayu Temaja⁵

⁵IKIP Saraswati, Indonesia

Corresponding Author: diputrabaqus@gmail.com

Abstract

Mathematics and culture are something that cannot be avoided in everyday life. Mathematics and culture are interrelated because mathematics is knowledge humans use to solve everyday problems. In contrast, culture is a complete and comprehensive unity that applies to society. However, sometimes mathematics is seen as outside of everyday life. Ethnomathematics is a mathematical concept that exists in a culture. The presence of mathematics with cultural nuances will make a significant contribution to mathematics learning. One of the ethnomathematics objects in Balinese Hindu culture is the Otonan. Otonan is a birth ceremony carried out by the Balinese people, based on Panca Wara, Sapta Wara, and Wuku in the Balinese calendar system. In determining Otonan, the least common multiple of the numbers 5, 7, 30 and repeated (cycles) are calculated so that the count for the Otonan ceremony is held every 210 days. Meanwhile, in determining Panca Wara, Sapta Wara and Wuku in Otonan, modulo (mod) numbers are used, namely modulo 5, modulo 7 and modulo 30. Ethnomathematics is very important; apart from being a learning material for students, it also functions as a means of cultural preservation.

Keywords: Ethnomathematics; Otonan; Panca Wara; Sapta Wara; Wuku.



INTRODUCTION

Science and technology are increasingly developing along with the times, which makes a significant contribution to developing educational technology. In the midst of developments in educational technology, the educational curriculum also demands cultural involvement in learning at school so that students can become a generation of character and are able to maintain and preserve culture as the basis of national character.

Education is essential for a nation to move towards an advanced civilization that can compete with other countries. Every human being needs education to avoid backwardness in accordance with the objectives of National Education, namely to educate the life of the nation and develop the Indonesian human being as a whole, namely a human being who has faith and devotion to God Almighty and has noble character, has knowledge and skills, physical and spiritual health, personality, who is stable and independent as well as a sense of social and national responsibility (Yassa, 2018).

Achieving national educational goals requires teacher creativity to provide meaningful learning to students and help students understand the abstractness of objects requiring various things that are close to students' daily lives. One thing that can be done is to provide space for students to be given contextual solutions through culture-based learning (Nanga & Suwarsono, 2019).

The implementation of culture-based learning to meet national educational standards enriched with comparative and competitive advantages based on noble cultural values so that students can actively develop their potential so that they become superior, intelligent, visionary, sensitive to the environment and cultural diversity, and responsive human beings towards the environment and cultural diversity, as well as being responsive to world developments (Felani, 2019). Indonesia is known for its cultural diversity, which is very aesthetic and cannot be found elsewhere. Culture contains elements of educational material, namely mathematics. This culture and mathematics are summarized in ethnomathematics. However, most people don't realize that mathematics and culture are two things that are closely related. But sometimes mathematics is seen as not connected to everyday life. When teaching formal mathematics (school mathematics), teachers should start by exploring the informal mathematical knowledge that students have acquired and the lives of the people around where they live. The environment can be a source of mathematical problems in real life. One of these environments is culture. Mathematics in culture is known as ethnomathematics.



Ethnomathematics is a mathematical concept that exists in a culture (Abi, 2015; Puspawati & Putra, 2014). The presence of mathematics with cultural nuances will significantly contribute to mathematics learning; one example can be taken from the traditional game of marbles. The traditional game of marbles has ethnomathematics related to mathematical concepts, including geometric concepts such as circles, balls, triangles and the concept of distance. These mathematical concepts can be used to introduce and understand the concepts of geometry and distance through local culture (Pratiwi & Pujiastuti, 2020). Ethnomathematics can be divided into six basic activities that can always be found in several cultural groups. The six mathematical activities are counting, determining location, measuring, designing, playing, and explaining.

Mathematics has been constructed from human understanding of the world empirically, with this experience processed analytically through experience in cognitive structures to form mathematical concepts easily understood by people and can be manipulated precisely using mathematical language or valuable mathematical notation. This concept is obtained from the thinking process; therefore, logic is the basis for forming mathematics (Hardy, 1959; Sukirman, 2004; Rahmah, 2018).

The digital revolution and the era of technological disruption are other terms used in Industry 4.0. It is called the digital revolution because of the proliferation of computers and the automation of recording in all fields (Ghufron, 2018). The acceleration of digitalization development. Industrial Revolution 4.0 makes it easier to access information. This easy access can have positive and negative impacts on cultural preservation, for example, because of globalization's influence, which allows the process of cultural assimilation and acculturation to accelerate very quickly. The worrying effect is the emergence of shame among the younger generation towards their own culture. The view of lack of technological knowledge may haunt the next generation, who should strive to be the holders of this nation's identity in the future.

Looking at the facts above, what needs to be considered is the role of mathematics educators at various levels of education to contribute to the preservation and advancement of culture. In order to answer this question, the presence of the concept or field of study of ethnomathematics is one way to show this contribution. Ethnomathematics is very suitable to be applied in the era of the Industrial Revolution 4.0, on the occasion of the development of digitalization; apart from being able to be a means of preserving culture, it also functions as a breaker for students and the wider community always thinks that the implementation of mathematics lessons in everyday life is only limited to a small scope or just simple things.



Therefore, it is essential to promote ethnomathematics as a teaching material at every level of education. This article explored ethnomathematics in Balinese culture, namely Otonan, in the Balinese calendar system. Otonan is a birth ceremony carried out by the Balinese people, based on Panca Wara, Sapta Wara, and Wuku in the Balinese calendar system. Panca Wara is a five-day cycle in Wewaran, Sapta Wara is a seven-day cycle in Wewaran, and Wuku is a thirty-day cycle in Wewaran.

METHOD

The type of research carried out was explorative research, namely research by conducting searches, especially in strengthening concepts used in the broader research scope with a greater conceptual reach (Yusuf, 2022).

This research was essential and aimed to obtain information related to Ethnomathematics about Otonan in the Balinese calendar system. Therefore, the design of this research was exploratory. Exploratory research seeks to get information and data regarding things that have yet to be discovered.

The data about Ethnomathematics were collected through literature studies and interviews. A literature study examined in-depth Otonan in the Balinese calendar system. Interviews were conducted with several people who have expertise in compiling the Balinese Calendar to clarify the data obtained through the literature study. The data on Ethnomathematics were analyzed descriptively.

DISCUSSION

ETHNOMATHEMATICS

Ethnomathematics consists of the word “ethno,” which means something comprehensive that refers to the socio-cultural context, including language, jargon, codes of behavior, myths and symbols; the word “Mathema,” which has the means of explaining, knowing, understanding, and carrying out activities such as coding, measuring, classifying, inferring, and modeling and the suffix “tics” comes from techne, and means the same as technique. Therefore, ethnomathematics has a broader meaning than ethno (ethnicity), so linguistically, ethnomathematics can be defined as the cultural anthropology of mathematics and mathematics education (Iskandar, 2021).

Ethnomathematics is a study that examines the relationship between mathematics and culture (Diputra et al., 2023). Mathematics as a basic science is developing in all countries. Each



country has a different culture, so the development of mathematics is different because the existing culture influences it.

Ethnomathematics is a study that examines the way a group of people in a particular culture understands, expresses, and uses the concepts and practices of their culture, which researchers describe as mathematical.

Ethnomathematics is also defined as mathematics used by social/cultural groups, such as urban and rural communities, groups of workers/laborers, professional groups, children of a certain age, indigenous communities, and many other groups identified as targets/common goals and traditions of the group (D'Ambrosio, 2001). Apart from that, ethnomathematics is also defined as research that connects mathematics or mathematics education and its relationship with social fields and cultural backgrounds, namely research that shows how mathematics is produced, transferred, disseminated and specialized in various cultural systems.

D'Ambrosio (2001) added that ethnomathematics in learning activities should be used as a tool to support student solidarity and cooperation. Apart from that, the main goal of ethnomathematics is to build a society free from barbarity, arrogance, intolerance, discrimination, injustice, bigotry and hatred, so that ethnomathematics is expected to foster peace among humanity.

According to the researchers, the definition of ethnomathematics is a study that examines mathematics in a culture, where mathematical knowledge transferred and disseminated into the cultural system of society.

Otonan

In the Sejarah Budaya article (2010), it is said that otonan comes from the Old Javanese language, which has become a Balinese vocabulary derived from the word "wetu" or "metu," which means to come out, be born, or become incarnate. From the word "wetu," it becomes "weton," which then changes to "oton" or "otonan."

Otonan is a birth ceremony (birthday) carried out by the Balinese (Sudarsana, 2010). The Otonan ceremony is carried out based on birth in the Wuku of the Balinese calendar. Its implementation coincides with Sapta Wara and Panca Wara. This ceremony aims to atone for previous mistakes and bad things so that life can reach a more perfect life.



WARA

In Singarajapost.com, it is said that wara is a daily unit, consisting of eka wara (day in one daily cycle), dwi wara (day in two daily cycles), to dase wara (day in ten daily cycles). The following are the names of the Wewaran that apply in Balinese Hindu society:

1. Eka Wara: luang
2. Dwi Wara: menga, pepet
3. Tri Wara: pasah, beteng, kajeng
4. Catur Wara: sri, laba, jaya, mandala
5. Panca Wara: umanis, pahing, pon, wage, kliwon
6. Sad Wara: tungleh, aryang, wurukung, was, maulu
7. Sapta Wara: redite, coma, anggara, budha, wrehaspati, sukra, saniscara
8. Asta Wara: sri, indra, guru, yama, ludra, brahma, kala, uma
9. Sanga Wara: dangu, jangur, gigis, nohan, ogan, erangan, tulus, dadi
10. Dasa Wara: pandita, pati, suka, dukha, sri, manuh, manusa, raja, dewa, raksasa

This article discussed only Panca Wara and Sapta Wara. Panca Wara consists of two words: Panca and Wara. Panca means five, so Panca Wara is the five daily cycles in Wewaran. The names of the days in Panca Wara are as follows.

1. Umanis
2. Pahing
3. Pon
4. Wage
5. Kliwon

Sapta Wara consists of two words, namely, Sapta and Wara. Sapta means seven, so Sapta Wara is the seven daily cycles in wewaran. The names of the days of the Sapta Wara are different from the names of the days in the Gregorian calendar system, even though the system is the same and can be compared.

The names of the days in Sapta Wara are aligned with the names of days in the Gregorian calendar system:



Table 1. Names of days in Sapta Wara and the Gregorian calendar

Days in Sapta Wara	Days in the Gregorian Calendar
Some	Monday
Anggara	Tuesday
Buda	Wednesday
Wraspati	Thursday
Sukra	Friday
Saniscara	Saturday
Redite	Sunday

WUKU

Sejarah Budaya (2019) says that Wuku is a count of numbers based on the number cycle in one week or seven days. In this number calculation, Wuku has 30 names recycled every or after 210 days ($7 \times 30 = 210$). Wuku is the name of a time cycle that lasts 30 weeks. One week or week consists of seven days. The weeks of Wuku are:

1. Sinta
2. Landep
3. Ukir
4. Kulantir
5. Taulu
6. Gumbreg
7. Wariga
8. Warigadian
9. Julungwangi
10. Sungsang
11. Dunggulan
12. Kuningan
13. Langkir
14. Medangsia
15. Pujut
16. Pahang



17. Kerulut
18. Merakih
19. Tambir
20. Medangkungan
21. Matal
22. Uye
23. Menail
24. Perangbakat
25. Bala
26. Ugu
27. Wayang
28. Kelau
29. Dukut
30. Watugunung

Otonan Balinese Calendar Ethnomathematics Activities in Otonan

Otonan uses counting activities. The mathematical calculation activity in Otonan is calculating common multiples. The Balinese calendar system uses a repetition process. The Panca Wara repeats every 5 days, consisting of: (Umanis, Paing, Pon, Wage, and Kliwon). In comparison, the Sapta Wara repeats every 7 days consisting of: (Soma, Anggara, Budha, Wrespati, Sukra, Saniscara, Redite), for example:

1. A person is born who is born on Saniscara–Kliwon, meaning the meeting of the Panca Wara and Sapta Wara. Hence, calculating the birth uses the least common multiple of the numbers 5 and 7. The calculation is as follows.



5	7
1	7
1	1

The least common multiple of 5 and 7 is $5 \times 7 = 35$

So, the Otonan ceremony born on Saniscara-Kliwon is held every 35 days.



2. A person was born on Saniscara-Kliwon-Gumbreg, meaning the meeting between Panca Wara, Sapta Wara, and Wuku. Hence, the calculation of his birth uses the least common multiple of the numbers 5, 7, and 30. The calculation is as follows.

	5	7	30
	5	7	15
3	5	7	5
5	1	7	1
7	1	1	1

The least common multiple of 5, 7, and 30 is $2 \times 3 \times 5 \times 7 = 210$

So, the otonan ceremony, born on Saniscara-Kliwon-Gumbreg, is held every 210 days or 6 Balinese months.

Determining Otonan Based on Date of Birth

The calculation in determining the Panca Wara, Sapta Wara, and Wuku in a person's Otonan based on birth is as follows:

Determining the Panca Wara

In determining the Panca Wara, if the date is known, three things must be taken into account: (1) Modulo 5 system, (2) Normal Year, (3) Leap Year. This system only uses five number symbols: 0, 1, 2, 3, and 4. The sum in the modulo 5 system is the same as an ordinary sum, except if the sum is greater than 4, we divide that sum by 4 and use the remainder instead of the usual amount. Therefore, $1 + 2 = 3$, but $4 + 2 = 1$ because if 6 is divided by 5, the remainder is 1.

Normal and leap years are also influenced in determining the Panca Wara. A normal year with 365 days means $365 = 0 \pmod{5}$. A leap year with 366 days means $366 = 1 \pmod{5}$. The concept is also the same: count the number of days from the first day, the first month, and the first year to the date, month, and year you want to find the Panca Wara for and look for the remainder.

Below is a table of addition with modulo 5.



Table 2. Summing up from the modulo 5 system

+	0	1	2	3	4
0	0	1	2	3	4
1	1	2	3	4	0
2	2	3	4	0	1
3	4	4	0	1	2
4	4	0	1	2	3

Remember that many days in a leap year are different from normal years.

Table 3. Number of days per month

Month	Normal Year	Leap Year
January	31	31
February	28	29
March	31	31
April	30	30
May	31	31
June	30	30
July	31	31
August	31	31
September	30	30
October	31	31
November	30	30
December	31	31

Table 4. Number of days in January

Month	Normal Year	Leap Year
January	0	0
February	31	31
March	59	60
April	90	91

May	120	121
June	151	152
July	181	182
August	212	213
September	243	244
October	273	274
November	304	305
December	334	335

A remainder table is obtained from the experimental results determining the Panca Wara.

Table 5. Remainder that determines Panca Wara

Remain	Panca Wara
0	Umanis
1	Paing
2	Pon
3	Wage
4	Kliwon

After knowing the Modulo 5 system, we can create a formula to find the day or Panca Wara of the desired date, month, and year. In principle, the formula is the number of all the days of the Gregorian calendar starting from day 1, month 1, and year 1 to the date, month, and year that you want to find the Panca Wara. Count and divide by 5, and see the remainder.

The formula for finding the Panca Wara, namely:

$$A + (366 \times B) + (365 \times C) = S \pmod{5}$$

or

$$A + B = S \pmod{5}$$

Description: A = Many days from January 1st

B = Many leap years, namely the most significant integer of



$$\frac{(\text{year} - 1)}{4}$$

C = Many normal years, namely $(\text{year} - 1 - B)$

S = Remainder of division by modulo 5

For example:

What Panca Wara do people born on March 13 1997?

Answer:

People born on March 13, 1997.

It can be obtained:

$$A = 13 + 59 = 72$$

$$B = \frac{(1997 - 1)}{4} = \frac{1996}{4} = 499$$

$$C = 1997 - 1 - 499 = 1497$$

Method I:

$$A + (366 \times B) + (365 \times C) = S \pmod{5}$$

$$72 + (366 \times 499) + (365 \times 1497) = S \pmod{5}$$

$$72 + 182634 + 546405 = S \pmod{5}$$

$$729111 = S \pmod{5}$$

$$729111 = 1 \pmod{5}$$

$$S = 1$$

Because the remainder is 1, from Table 5, we get that the Panca Wara of people born on March 13 1997 are Paing.

Method II:

$$A + B = S \pmod{5}$$

$$72 + 499 = S \pmod{5}$$

$$571 = S \pmod{5}$$

$$571 = 1 \pmod{5}$$



$$S = 1$$

Because the remainder is 1, from Table 5, we get that the Panca Wara of people born on March 13 1997 are Paing.

Determining Sapta Wara

We already know that Sapta Wara is the seven daily cycles of Wewaran, which consists of soma, anggara, buda, wraspati, sukra, saniscara, and redite. Because Sapta Wara consists of 7 parts, we have to know the modulo 7 system, where the modulo 7 system plays a vital role in determining Sapta Wara.

This system only uses seven number symbols: 0, 1, 2, 3, 4, 5, and 6. The sum in the modulo 7 system is the same as an ordinary sum, except that if the sum is greater than 6, we divide the sum by 7 and use the remainder in place of the regular amount. Therefore, $1 + 3 = 4$, but $5 + 4 = 2$ because if 9 is divided by 7, the remainder is 2.

Below is a table of additions from the modulo 7 system.

Table 6. Summing up of the modulo 7 system

+	0	1	2	3	4	5	6
0	0	1	2	3	4	5	6
1	1	2	3	4	5	6	0
2	2	3	4	5	6	0	1
3	3	4	5	6	0	1	2
4	4	5	6	0	1	2	3
5	5	6	0	1	2	3	4
6	6	0	1	2	3	4	5

After knowing the modulo 7 system, we can create a formula to find the day or Sapta Wara of the desired date, month, and year. In principle, the formula is the number of all days of the Gregorian calendar starting from the 1st, month, and year 1 to the date, month, and year that the Sapta Wara is to be searched for, count and divide by 7, and find the remainder.

The researchers have carried out several experiments, and they have found that if the



remainder is zero, it falls on saniscara (Saturday), if the remainder is one, it falls on redite (Sunday), and so on until if the remainder is 6, it falls on sukra (Friday). This can be seen in the table below.

Tabel 7. Remainder that determines Sapta Wara

0	Saturday	Saniscara
1	Sunday	Redite
2	Monday	Soma
3	Tuesday	Anggara
4	Wednesday	Budha
5	Thursday	Wraspati
6	Friday	Sukra

Remember that the number of days in a normal year is 365, meaning $365 \equiv 1 \pmod{7}$, while the number of days in a leap year is 366, meaning $366 \equiv 2 \pmod{7}$. A particular year can be expressed as the sum of normal and leap years so that the number of days can also be counted.

For example, A year = B normal year + C leap year so we can count the number of days. With the description above, we can make a formula, namely:

$$A + (366 \times B) + (365 \times C) = S \pmod{7}$$

or

$$A + B + D = S \pmod{7}$$

Description:

A = Many days from January 1st

B = Many leap years, namely most significant integer of $\frac{(\text{year}-1)}{4}$

C = Many normal years, namely $(\text{year} - 1 - B)$

D = Year - 1

S = Remainder of division by modulo 7

For example:

What Sapta Wara do people born on March 13 1997?

Answer:

People born on March 13, 1997.



It can be obtained:

$$A = 13 + 59 = 72$$

$$B = \frac{(1997 - 1)}{4} = \frac{1996}{4} = 499$$

$$C = 1997 - 1 - 499 = 1497$$

$$D = 1997 - 1 = 1996$$

Method I:

$$A + (366 \times B) + (365 \times C) = S \pmod{7}$$

$$72 + (366 \times 499) + (365 \times 1497) = S \pmod{7}$$

$$72 + 182634 + 546405 = S \pmod{7}$$

$$729111 = S \pmod{7}$$

$$729111 = 5 \pmod{7}$$

$$S = 5$$

Because the remainder is 5, as shown in Table 5. We get Sapta Wara, a person born on March 13 1997 is Wraspati (Thursday).

Method II:

$$A + B + D = S \pmod{7}$$

$$72 + 499 + 1996 = S \pmod{7}$$

$$2567 = S \pmod{7}$$

$$2567 = 5 \pmod{7}$$

$$S = 5$$

Because the remainder is 5, from table 7, we get the Sapta Wara of people born on March 13 1997, namely Wraspati (Thursday).

Determining the Wuku

Determining Wuku is not like determining Sapta Wara or Panca Wara because, in addition to the 30 Wuku, there are 7 days in 1 Wuku. So, here, we will work in 2 steps to determine the Wuku on a certain date, month, and year.

The first step is the same as finding Sapta Wara or Panca Wara, namely counting the number of days from the first day, first month, and first year to the desired date, month, and year. After knowing the number of days, we add 6, then divide by 7, and take the largest integer. Now,



we find the remainder of division with modulo 30. The results obtained can be adjusted to the table below.

Table 8. Remainder that determines wuku

Remainder	Wuku
0	Pujut
1	Pahang
2	Klurut
3	Mrekaih
4	Tambir
5	Medangkungan
6	Matal
7	Uye
8	Menail
9	Prangbakat
10	Bala
11	Ugu
12	Wayang
13	Klau
14	Dukut
15	Watu gunung
16	Sinta
17	Landep
18	Ukir
19	Kulantir
20	Tolu
21	Gumbreg
22	Wariga
23	Warigadean
24	Juluwangi
25	Sungsang



26	Dungulan
27	Kuningan
28	Langkir
29	Medangsia

The formula that can be used is

$$A + (366 \times B) + (365 \times C) + 6 = D$$

$$D = E(\text{mod } 7)$$

$$F = \frac{D - E}{7}$$

$$F = S(\text{mod } 30)$$

Description:

A = Many days from January 1st

B = Many leap years, namely the most significant integer of $\frac{(\text{year}-1)}{4}$

C = Many normal years, namely (year – 1 – B)

D = The number of days from day 1, month 1 and year 1 is added to 6

E = The remainder of the number of days divided by 6 is added modulo 7

F = The largest integer from dividing D by 7

S = Remainder of division by modulo 30

For example:

What Wuku do people born on March 13 1997 fall into?

Answer:

People born on March 13, 1997.

It can be obtained:

$$A = 13 + 59 = 72$$

$$B = \frac{(1997 - 1)}{4} = \frac{1996}{4} = 499$$

$$C = 1997 - 1 - 499 = 1497$$

$$D = A + (366 \times B) + (365 \times C) + 6$$

$$D = 72 + (366 \times 499) + (365 \times 1497) + 6$$



$$D = 729117$$

$$729117 = E \pmod{7}$$

$$104159 = 4 \pmod{7}$$

$$E = 4$$

$$F = \frac{D-E}{7}$$

$$F = \frac{729117-4}{7} = \frac{729113}{7}$$

$$F = \frac{729113}{7} = 104159$$

$$104159 = S \pmod{30}$$

So, the most significant month number is $F = 104159$

$$104159 = 29 \pmod{30}$$

$$S = 29$$

According to Table 8, the Wuku of a person born on March 13, 1997, is Wuku Medangsia.

Benefits of Ethnomathematics for Students' Learning

With ethnomathematics, students can implement mathematics lessons into social life, such as determining Otonan on the Balinese calendar. In determining Otonan, mathematical elements include calculating the least common multiple and modulo numbers. Therefore, Otonan can be used as a source of mathematics learning in the classroom so that mathematics learning becomes unique, engaging, and contextual.

Ethnomathematics studies in Balinese culture support implementing mathematics learning, especially at the basic education level. Primarily, for schools that implement the Merdeka Curriculum in Bali, learning that utilizes cultural elements supports the formation of student character and can also be used as a tool to support cooperative solidarity in society so that students become more motivated to learn and indirectly become more love the culture they have.

CONCLUSION

Education cannot be separated from the culture of society itself. It is evident from the many cultures that, apart from containing aesthetic and unique elements, indirectly also contain mathematics teaching. Learning that links culture with mathematics is called ethnomathematics. For example, determining a person's Otonan based on the Balinese calendar system can be used



as a unique, aesthetic and contextual mathematics learning medium in learning to calculate least common multiples, while in determining Panca Wara, Sapta Wara and Wuku, the first step we have to do is count the number of days from day 1, month 1, and year 1 to the desired date, month and year (which will be searched). After knowing the number of days, to determine Panca Wara, we look for the remainder of modulo five of the number of days and adjust it to Table 5.

Meanwhile, to determine Sapta Wara, we look for the remainder modulo seven of the number of days and adjust it to Table 7. Likewise, in determining Wuku, there are many days we add 6, then divide by 7 and take the largest integer. After that, find the remainder of the division with modulo 30. The results obtained can be adjusted to Table 8. Ethnomathematics is very important; apart from being a learning material for students, it also serves to preserve culture for the next generation who will hold the foundation of this nation in the future.

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