Remembering the hindu festivities mathematically by the balinese using integer operations and least common multiple

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Abstract. Ethnomathematics is considered as a new study in mathematic education. As a study, numerous regions in this world starts to explore through ethnomathematics, including Indonesia. As the intersection between mathematics and mathematical modelling and culture, ethnomathematics exists in various society’s cultural elements, including in the Balinese Hindus’ festivities. To find the mathematical concept used in determining the festivity days, the researcher(s) conducted ethnographic research in \textit{Bali Mula} society in Kintamani District, Bali. Participation observation, in-depth interview, and literature and documentation were used in collecting the data. As the result, the researcher(s) revealed that the mathematical concept used is integer operations, least common multiple, mixed fraction, and number sequences. Since it contains mathematical concept used in junior high, thus ethnomathematics of “4-hindu’s festivities” may be used as context in mathematics learning. By using ethnomathematics as the context, the researcher(s) expect that it will help teachers in motivation their students to learn mathematics.

1. Introduction

Bali is the name of an island in Indonesia. The majority of people in this island are Hindus Balinese tribes. There, religion and customs unite themselves and transform into the unique characteristics of Balinese people. Also, supported by its extraordinary nature, Bali becomes both national and international tourism destination. Its abundant cultures at least affects Balinese people’s mindset, including the ability in mathematics. However, someone’s ability in mathematics is affected by his cultural background, and hung on what he sees and feels or experiences \cite{1}.

Mathematics, as one of disciplines, is definitely correlated with culture. There are people’s daily activities with mathematical applications within. For example, people in \textit{Kudus} has used the concept of circle, triangle, trapezium, rectangle, block, square pyramid and triangular prism in their daily life \cite{2}.

The correlation between mathematics and culture is called as Ethnomathematics. It combines mathematics practiced, adopted and combined within cultural practice by numerous communities ordinarily \cite{3}. Mathematical concept can also be learnt in each stage that allows the learner to attach it in the cultures of Balinese society or others.

To date, there are a lot of researches on Ethnomathematics in mathematics and mathematics education. As the research area, Ethnomatematics may refer to a research to describe how mathematics...
is created, taught, emphasized and specialized in cultural system [4]. Thus, such researches may be in the form of exploration or its use.

As the attempt to use ethnomathematics, the thing we can learn from mathematics teacher is how to use ethnomathematics in mathematical learning. It is possible since children who go to school basically do not establish themselves in “tabula rasa”. They have abundant collection of ideas and experiences according to cultural aground and daily activities of the integral part of cognitive function, and both of them are visible and popping up [5].

Ethnomathematics may also be advantageous in the development of mathematics curriculum. This is in line with a thought mentioning that it very makes sense to integrate ethnomathematics an mathematics curriculum, because such integration may result in a comprehended and respected noble value within a culture [4]. Besides, the use of facts in students’ daily life makes mathematical learning be more meaningful and exciting [6].

The above mentioned experts’ perspective implies the significance of the investigation of the noble value contained in society’s culture to improve the education quality, therefore, exploration by ethnomathematics is the initial step to figure out the concepts of mathematics taught at school in the cultural activities of Bali Mula Society. As conducted by the previous researchers, the research(s) observed each cultural activity to find out the types of applied mathematical concepts.

The Ethnomathematics of Balinese Sculptors applied similarity, shifting, and rotation; meanwhile, the Ethnomathematics of Balinese Calendar Compiler adopted repetition and confluence [7] On the other hand, ethnomathematics applied in Balinese webbing may be found in the use of tessellation in webbing pattern. The existing pattern uses the concept of rectangle, square, and regular tessellation [8].

According to the above notion, the research(s) conducted an ethnographic research to explore the ethnomathematics deeper, especially in the society of Bali Mula. The religious system in determining festivity days is the main focus in this research. Furthermore, this research aimed to figure out the types of mathematical concepts used by Balinese society in determining their festivities. After the researcher(s) found the mathematical concepts in the cultural elements, it was mapped with the mathematics materials used in the corresponding education levels. It is because Ethnomathematics will be relevant to mathematics learning used at schools [9].

2. Method

This research is conducted in qualitative way. A qualitative research may refer to as approach to explore and comprehend the meaning of social issues within the society, either individually or in group [10]. Specifically, this research is an ethnographic research with Bali Mula society in an area as a study. From March to June 2017, the researchers collected the data by using participant observation technique, in depth interviews, and documentation. In detail, the researchers described the data collection as follow:

**Table 1. Data Collection Technique**

| Data collection technique | Situation |
|---------------------------|-----------|
| Participant observation   | Interacted and discussed with Bali Mula society in the area of Kintamani; participated in festivities. |
| In dept interview         | Asked several questions relating to festivities or other sacred days. The researchers asked such question to illiterate and literate elderly people, village figures, youth, and junior high students. |
| Literature study and Documentation | Looked for books related to Hindus festivities, learnt then matched them with the result of observation and interview. |

The data resources in this research are Bali Mula society living in the area of Batur Global Geopark, especially in Songan Village A and B, Terunyan, and Belandingan.
3. Result and Discussion

There are many festivities in Hindu. There are daily festivities, which are based on wewaran, pananggal and panglong, pawukon, and sasih. Daily festivities are in the form of Yadnya Sesa and Tri Sandya. Yadnya Sesa refers to festivities of food offerings (in small amount) before eating or after cooking.

Generally, wewaran-based festivities are divided into two categories: based on 3-days week (triwara) and 5-days week (pancawara); and 5-days week (pancawara) and 7-days week (saptawara). Wewaran refers to the rhythm of days based on the rhythm of universe. In wewaran, there are 10 types of week that has been preserved by Balinese society. The naming is according to the number of days in each week, they are 1-day week (ekawara), 2-days week (dwiwara), 3-days week (triwara), and so on until 10-days week (dasawara). Meanwhile, for society living in several areas in Java island and West Java, they commonly knows two of those week types: 5-days week and 7-days week.

Purnama (full moon) and Tilem (new moon) are the festivities based on pananggal and panglong. Furthermore, Kajeng Kliwon is festivities determined based on the confluence of triwara and pancawara. One Kajeng is among the three days in triwara (Pasah, Beteng, Kajeng). Kliwon is a day in pancawara (Umanis, Paing, Pon, Wage, Kliwon).

Based on the confluence of pancawara and saptawara, there are four festivities: Buda Kliwon, Saniscara Kliwon, Buda Wage (Buda Cemeng), and Anggara Kliwon (Anggara Kasih). Redite = Sunday, Coma = Monday, Anggara = Tuesday, Buda = Wednesday, Wraspati = Thursday, Sukra = Friday, and Saniscara = Saturday are name of days in saptawara. The Cigugur society also used the combination of pancawara dan saptawara to count their rice harvesting period [11].

Each one cycle of saptawara has its own name. There are 30 names for saptawara popularly called pawukuan or pawukon. So, one wuku occurs in 7 days started from Sunday to Saturday. The name of 30 wukus are as follow: 1. Sinta, 2. Landep, 3. Ukir, 4. Kulantir, 5. Tolu, 6. Gumbreg, 7. Wariga, 8. Warigadian, 9. Julungwangi, 10. Sungssang, 11. Dungulan, 12. Kuningan, 13. Langkir; 14. Medangsia, 15. Pujut, 16. Pahang, 17. Klurut, 18. Merakih, 19. Tambir, 20. Medangkungan, 21. Matal, 22. Uye, 23. Menail, 24. Prangbakat, 25. Bala, 26. Ugu, 27. Wayang, 28. Klau, 29. Dukut, dan 30. Watugumung.

Galungan and Kuningan are festiviries conducted based on pawukon. Meanwhile, festivities of Siwalatri dan Nyepi are commemorated based on sasih (month) in pranatamangsana, in which the former occurs in sasih kepitu (7th month) while the latter in sasih Kesanga (9th month).

Balinese Hindus depends such festivities on Desa-Kala-Patra. Such terms mean Place-Time-Situation. The term verily affects the festivities, mainly for Balinese Hindus living outside Bali Island. Other than the influence of Desa (place), Kala (time) also plays critical role. While time, in its largest scope, may refer to the exact time to conduct such festivities.

Considering numerous festivities, a mean for the purpose of remembering or calculating them are surely needed. Self calculation, moon’s position observation, wall calendar check, internet access, or android-based application are the means to determine the festivities. In this section, the researchers present how Bali Mula society in Kintamani figure out the 4-Hindus festivities (Buda Kliwon, Tumpek, Buda Cemeng, and Anggara Kasih).

a. Illiterate elderly people

Illiterate Bali Mula society in Kintamani memorize the 4-Hindus festivities by using wuku. They memorize the days of festivities in particular wukus. Of 4 festivities, 3 of them are more dominant in their memory. Those festivities are Buda Kliwon, Tumpek, and Anggara Kasih.
### Table 2. Matrix of 4-Hindus festivities within 210 days

| Saptawara | Redite | Coma | Anggara | Buda   | Wrespati | Sukra | Saniscara |
|-----------|--------|------|---------|--------|----------|-------|-----------|
| **Wuku**  |        |      |         |        |          |       |           |
| 1. Sinta  | Paing  | Pon  | Wage    | Kliwon | Umanis   | Paing | Pon       |
| 2. Landep | Wage   | Kliwon | Umanis | Paing | Pon | Wage | Kliwon |
| 3. Ukir   | Umanis | Paing | Pon     | Wage   | Kliwon   | Umanis | Paing     |
| 4. Kulantir | Pon | Wage   | Kliwon | Umanis | Paing | Pon | Wage     |
| 5. Tolu   | Kliwon | Umanis | Paing | Pon | Wage | Kliwon | Umanis |
| 6. Gumbreg | Paing | Pon | Wage | Kliwon | Umanis | Paing | Pon |
| 7. Wariga | Wage | Kliwon | Umanis | Paing | Pon | Wage | Kliwon |
| 8. Warigadian | Umanis | Paing | Pon | Wage | Kliwon | Umanis | Paing |
| 9. Julungwangi | Pon | Wage | Kliwon | Umanis | Paing | Pon | Wage |
| 10. Sungsang | Kliwon | Umanis | Paing | Pon | Wage | Kliwon | Umanis |
| 11. Dungulan | Paing | Pon | Wage | Kliwon | Umanis | Paing | Pon |
| 12. Kuningan | Wage | Kliwon | Umanis | Paing | Pon | Wage | Kliwon |
| 13. Langkir | Umanis | Paing | Pon | Wage | Kliwon | Umanis | Paing |
| 14. Medangsia | Pon | Wage | Kliwon | Umanis | Paing | Pon | Wage |
| 15. Pujut | Kliwon | Umanis | Paing | Pon | Wage | Kliwon | Umanis |
| 16. Pahang | Paing | Pon | Wage | Kliwon | Umanis | Paing | Pon |
| 17. Krulur | Wage | Kliwon | Umanis | Paing | Pon | Wage | Kliwon |
| 18. Merakih | Umanis | Paing | Pon | Wage | Kliwon | Umanis | Paing |
| 19. Tambir | Pon | Wage | Kliwon | Umanis | Paing | Pon | Wage |
| 20. Medangkungan | Kliwon | Umanis | Paing | Pon | Wage | Kliwon | Umanis |
| 21. Matai | Paing | Pon | Wage | Kliwon | Umanis | Paing | Pon |
| 22. Uye | Wage | Kliwon | Umanis | Paing | Pon | Wage | Kliwon |
| 23. Menail | Umanis | Paing | Pon | Wage | Kliwon | Umanis | Paing |
| 24. Prangbakat | Pon | Wage | Kliwon | Umanis | Paing | Pon | Wage |
| 25. Bala | Kliwon | Umanis | Paing | Pon | Wage | Kliwon | Umanis |
| 26. Ugu | Paing | Pon | Wage | Kliwon | Umanis | Paing | Pon |
| 27. Wayang | Wage | Kliwon | Umanis | Paing | Pon | Wage | Kliwon |
| 28. Klau | Umanis | Paing | Pon | Wage | Kliwon | Umanis | Paing |
| 29. Dukut | Pon | Wage | Kliwon | Umanis | Paing | Pon | Wage |
| 30. Watugunungan | Kliwon | Umanis | Paing | Pon | Wage | Kliwon | Umanis |

Somehow, there is interesting thing behind the correlation among such festivities. *Buda Kliwon* occurs 10 days before *Tumpek*, and so does *Tumpek* to *Anggara Kasih*. Such fact then becomes the guideline of the illiterate elderly people, for example, if today is *Buda Kliwon*, then *Tumpek* and *Anggara Kasih* will respectively occur in the next 10 and 20 days.
Since such festivities occur in sequence, those people may easily memorize them. For instance, if today is Buda Kliwon Sinta, Tumpek Landep and Anggara Kasih Kulantir will respectively occur in the next 10 and 20 days. With such guideline, the illiterate elderly people may easily determine the days for 4-Hindus festivities.

Besides, it is known that Buda Kliwon occurs in every 35 days and so do the other festivities. In other words, if today is Anggara Kasih, then the nearest Buda Kliwon and Tumpek will respectively occur in the next 15 and 25 days.

Similar with the other society, several important events related to family tend to be more memorable for Bali Mula society. Day of birth, marriage and other events are more likely quite memorable. The most common event is birth day, which is well known as “Otonan”. Otonan will occur every 210 days or 6 months according to Balinese month.

To memorize his otonan, one usually uses the guideline of the 4-Hindues festivities. The elderly people will find out the nearest festivities. For example, for a child born in Anggara Umanis Landep, his otonan will occur 4 days before Tumpek Landep, not 6 days after Buda Kliwon Sinta.

The general question that new Hindus parents mostly find is “how old is your child?.” To properly answer such question, the parents will start to count it. The degree of difficulty in calculating such age can be categorized as follow: between the age of 1-210 days (0-6 months) and more than 6 months. For example, people who ask about the child’s age in following days:

1) \( \leq 6 \) months
   - On the day Anggara Kasih Kulantir of Anggara Kasih Kulantir occurs 10 days after Tumpek Landep(+10). The child is born 4 days before Tumpek Landep(+4). So, on the day of Anggara Kasih Kulantir, the child is 14 days. The mathematical operations used in this case is \( 4 + 10 = 14 \).
   - On the day of Coma Paing Warigadian Warigadian occur in the \( 8^{th} \) wuku. When the question comes on the day of Coma Paing Warigadian, then the guideline used should be Tumpek Wariga that has occurred two days before (+2). Tumpek Landep occurs 35 days (+35) before Tumpek Wariga. The child was born 4 days before Tumpek Landep(+4). So, on the day of Coma Paing Warigadian, the child is 41 days. The mathematical operations used in this case is \( 4 + 35 + 2 = 41 \).
   - On the day of Anggara Wage Ugu
Ugu occurs on the 26th wuku. When the question comes on the day of Anggara Wage Ugu, then the guideline used should be the next Buda Kliwon Ugu (-1). Buda Kliwon Sinta occurs 5 x 35 days before Buda Kliwon Ugu. The child was born 6 days after Buda Kliwon Sinta (-6). So, on the day of Coma Paing Warigadian, the child is 168 days. The mathematical operations used in this case is \(-1 + 5 \times 35 - 6 = (5 \times 35) - 7 = 168\).

In this case, parents tend to tell their kid’s age in this month unit: “7 days to five months”

2) > 6 months

- On Redite Umanis Ukir

Ukir exactly occurs after Landep. It is quite easy to answer question related to child’s age when such question comes on the day of Redite Umanis Ukir or the other day in Ukir wuku. Parents will celebrate the child’s birth day (otanan) by creating upakara according to their respective capability. Therefore, question related to age comes on the day of Redite Umanis ukir for a children who was born on the day Anggara Umanis Landep may be easily answered. The distance between Anggara Umanis Landep to Anggara Umanis Landep is 6 months (1 oton) or its multiple. Anggara Umanis Landep occurs 5 days before Redite Umanis Ukir. Thus, the child is 6 months 5 days or 12 months 5 days or 18 months 5 days on the day of corresponding Redite Umanis Ukir.

b. Literate society

1) Self-calculation.

People who are literate and have books as their reference may count the festivities days by themselves. There are standard rules specified in a printed book on how to count the 4-Hindus Festivities. Specifically, the method to determine Buda Keliwon, Tumpek, Buda Cemeng, and Anggara Kasih is by using the following formula [12]:

| The number of Wuku should be divided by 5, if |
|---------------------------------------------|
| The remainder is 1, thus it means the festivities day of Buda Keliwon |
| The remainder is 2, thus it means the festivities day of Tumpek |
| The remainder is 3, thus it means the festivities day of Buda Cemeng |
| The remainder is 4, thus it means the festivities day of Anggara Kasih |
| The remainder is 5, thus it means of Pengembang |

For example, Wuku Sinta containing 1 as the wuku number, then \(1 : 5 = 0\) with 1 as the remainder. So, in Wuku Sinta the festivities to celebrate is Buda Kliwon.

The calculation above may be simplified by ordering all of wukus in sequence by using fingers. It starts with folding the thumb for Wuku Sinta, index finger for Wuku Landep so on until the five wukus calculated.

```
Buda Kliwon
  |  |
  |  |
  |  |
  |  |
  |  |
Buda Cemeng
  |  |
  |  |
  |  |
  |  |
  |  |
Tumpek
  |  |
  |  |
  |  |
  |  |
  |  |
Anggara kasih
  |  |
  |  |
  |  |
  |  |
  |  |
Pengembang
```

Figure 1. Calculation 4-Hindus Festivities using fingers
Since there are 30 Wuku, it means that within six months (210 days), there are 6 Buda Kliwon days. Similar pattern also occurs to Tumpek, Buda Cemeng, dan Anggara Kasih. Buda Kliwon that are celebrated in Wuku (1) Sinta, (6) Gumbreg, (11) Dungulan, (16) Pahang, (21) Matal, and (26) Ugu. Meanwhile, the festivities day of Tumpek occurs in Wuku (2) Landep, (7) Wariga, (12) Kuningan, (17) Klurut, (22) Uye, and (27) Wayang. The festivities of Buda Cemeng occurs in Wuku (3) Ukir, (8) Warigadian, (13) Langkir, (18) Merakih, (23) Menail, and (28) Klau. Furthermore, the day of Anggara Kasih occurs in Wuku (4) Kulantir, (9) Julungwangi, (14) Medangsia, (19) Tambir, (24) Prangbakat, and (29) Dukut. Moreover, wuku (5) Tolu, (10) Sungang, (15) Pujut, (20) Medangkungan, (25) Bala, and (30) Watugunung are called Pengembang.

There are mathematical concepts for junior high that is in line with the above mentioned method. The concepts are:

a) Sequences
In the existing 30 wukus, the sequence containing Buda Kliwon, Saniscara Kliwon, Buda Wage, and Anggara Kliwon forms the following patterns:
   a) 1st, 6th, 11th, 16th, 21th and 26th wuku refers to the festivities day of Buda Kliwon.
   b) 2nd, 7th, 12th, 17th, 22nd and 27th wuku refers to the festivities day of Tumpek.
   c) 3rd, 8th, 13th, 18th, 23rd, and 28th wuku refers to the festivities day of Buda Cemeng.
   d) 4th, 9th, 14th, 24th, and 29th refers to the festivities day of Anggara Kasih.
   The patterns above are the real examples of pattern or sequence.

b) Fraction and mixed fraction
There are 30 wukus in Balinese six months. If it is put in sequence from 1 to 30, there will be 30 wuku numbers. In reference to the condition of wuku number division by 5 and the remainders, then the mixed fraction is:

\[
\begin{align*}
1:5 &= \frac{1}{5} \\
6:5 &= 1\frac{1}{5} \\
11:5 &= 2\frac{1}{5} \\
16:5 &= 3\frac{1}{5} \\
21:5 &= 4\frac{1}{5} \\
26:5 &= 5\frac{1}{5}
\end{align*}
\]

Represents Buda Kliwon

\[
\begin{align*}
2:5 &= \frac{2}{5} \\
7:5 &= 1\frac{2}{5} \\
12:5 &= 2\frac{2}{5} \\
17:5 &= 3\frac{2}{5} \\
22:5 &= 4\frac{2}{5} \\
27:5 &= 5\frac{2}{5}
\end{align*}
\]

Represents Tumpek
\[
\begin{align*}
3:5 &= \frac{3}{5} \\
8:5 &= \frac{1}{5} \\
13:5 &= \frac{2}{5} \\
18:5 &= \frac{3}{5} \\
23:5 &= \frac{4}{5} \\
28:5 &= \frac{5}{5}
\end{align*}
\]

\[
\begin{align*}
4:5 &= \frac{4}{5} \\
9:5 &= \frac{4}{5} \\
14:5 &= \frac{2}{5} \\
19:5 &= \frac{4}{5} \\
24:5 &= \frac{4}{5} \\
29:5 &= \frac{4}{5}
\end{align*}
\]

\(c\) Least Common Multiple

The days of 4 festivities are based on \textit{Pancawara} and \textit{Saptawara}. \textit{Buda Kliwon} is celebrated in the day of \textit{Buda} (\textit{Saptawara}) and \textit{Kliwon} (\textit{Pancawara}), while \textit{Tumpek} in the day of \textit{Saniscara} (\textit{Saptawara}) and \textit{Kliwon} (\textit{Pancawara}), and \textit{Anggara Kasih} in \textit{Anggara} (\textit{Saptawara}) and \textit{Kliwon} (\textit{Pancawara}). The determination of the sequence of the 4 festivities days can be calculated by using Least Common Multiple. Since the days in \textit{Saptawara} re-occur in each 7 days and \textit{Pancawara} in each 5 days, then the determination should use the least common multiple of 7 and 5, which results in 35 days.

2) Wall calendar

Most of Balinese society use wall calendar and so do others living outside Bali Island. Such calendar is called Balinese calendar. Basically, some of the contents in such calendar are not originally inherited from Balinese culture. Combination and modernization exist within. The pattern of Balinese calendar is the same with the common Gregorian one [13].

One of the most popular printed Balinese calendars is made by the late I Ketut Bambang Geder Rawi and his sons.

\textbf{Figure 2.} Balinese wall calendar

In order to be able to read such calendar, the competence of table reading is required. Similar with the common wall calendar, there are 5 columns and 7 rows in each month. The rows show \textit{saptawara} while the columns indicate \textit{wuku}. The information about \textit{pancawara} is
presented in the square as the confluence of row and column. For example, in Wednesday row (Buda), the second column showing the date of 10 May 2017 refers to the day of Kliwon (Pancawara). Therefore, the festivities day of Buda kliwon occurs in such day.

3) Modern application
The information may be accessed on a website. Other than database-based on website, this information can also be accessed through application. There are various choices of android-based application containing the information of Hindu festivities available on playstore.

4. Conclusions
Balinese Hindus society have many methods to figure out their festivities days. The differences between background and literacy also determine their distinctive methods. For illiterate society, they use their environmental observation as their guideline in determining the festivities days. Meanwhile, the literate society have more methods in determining such events, such as self-calculation, wall calendar check, moon's position observation, or internet access and android-based application. The calculation of the 4-Hindus Festivities (Buda Kliwon, Tumpek, Buda Cemeng, dan Anggara Kasih) may be done in mathematical concepts, they are: integers operations, least common multiple, mixed fractions and sequence. Since it fully contains mathematical concepts, the determination of the 4-Hindus Festivities may be used as the context in mathematical learning at junior high school. The researchers hope that such utilization may motivate the students in learning mathematics as mandated in the regulation of minister of education.

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