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Mathematical Model for Determining of Wuku Name in Javanese Culture in Indonesia

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Abstract: This study develops mathematical model for determining of Wuku name in Pawukon Saka and Pawukon Jawa. By utilizing the Chinese remainder problem, the generated model can be utilized to confirm the truth of the data carved in various inscriptions found in Indonesia. The established model can also be employed in deciding Wuku name in the inscriptions which do not contain Wuku names. As many as 28 inscriptions from prior to 1500 before christ era and a relatively new inscription are utilized as the media for application model generation. The result corrects of Wuku names in three inscriptions and confirms the truth of Wuku name writings in eight inscriptions. Among 17 inscriptions that do not have Wuku names, Wuku names of 11 of them can be decided and 6 of them cannot due to insufficiency of the data needed including Laguna Bay Inscription from Philippines. The name of Sadwara day of an inscription called Phallus Sukuh can be determined.

Key words: Pawukon, inscription, Wuku, the chinese remainder problem, mathematical model, determined

INTRODUCTION

Congruences of first degree necessary to calculate calendar in ancient China as early as the 2nd century AD (Kangsheng, 1988; Akintan, 2013; Ohashi, 2011). Javanese society uses Pawukon calendar which contains three dissertation names of Wuku. Those three types of days called Wewaran and consists of Pancaewara, Sadwara and Saptawara. Pancawara is a 5 days cycle, respectively consists of Paing, Pon, Wage, Kliwon and Legi. Sadwara is a 6 days cycle, respectively comprises of Tungle, Haryang, Wurukung, Paniron, Was and Mawulu. While Saptawara is 7 days cycle just as weekly cycle in BC or Hijriah calendars. The name of the days in Saptawara are Radite, Soma, Anggara, Buda, Respati, Sukra and Tumpak/Saniscara. Today, those names has already changed into Sunday, Monday, Tuesday, Wednesday, Thursday, Friday and Saturday (Persky, 2009; Sivaya, 1997).

In Pawukon calendar, the 3 types of Wewaran will run the cycle together at a time so that the combination of the three same days will repeat for every 210 days. Therefore, the cycle length of Pawukon calendar is 210 days and it is called as segrombol or sedhapur (Prabowo, 2014). Pawukon calendar naming occurred due to the use of the names of thirty Wukus in that calendar so that the Wuku will change regularly for every 7 days.

Pawukon calendar is not accompanied by date, month and year number. The time measurement in the form of days change is only signified by the 3 Wewaran and a Wuku. The first day on Pawukon calendar are Pahing, Tunglai, Radite and Wuku Sinta while the last day (the 210th day) are Umanis, Mawulu, Saniscara and Wuku Watugunung. The use of Pawukon calendar has been existed for at least, since the era of Mataram Hindu Kingdom (732 BC) up to now.

Prabowo and Wahyuni (2015) had developed a model for determining of Wuku names on Pawukon Saka by utilizing Javanese Mathematics (Unodiaku, 2013). The model generated is used to correct the truth of Wuku names on various inscriptions. One of the results is the presence of mistakes in the Wuku names writing on cicatih inscription where Wuku tambir is carved while it is supposed to be Wuku medangkungan. In this study, we will develop a mathematic model to determine the name of three types of Wewaran and Wuku names if the order number of day x is known by $0 \leq x \leq 209$.

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MATERIALS AND METHODS

This research employs literary reviews and inscriptions data review by taking inscriptions as the research objects. It is different from that used Javanese Mathematics to test the inscriptions. This study uses Mathematics to establish a model which can be utilized to determine the names of Wuku. The inscriptions utilized in this study employ the generated model.

RESULTS AND DISCUSSION

Mathematical model for Wewaran names: Taking x is the order number in Pawukon calendar. Taking the names of days for every Wewaran are a_1, a_2, a_3 by:

- $a_1 = 0$ = Paing
- $a_1 = 1$ = Pon
- $a_1 = 2$ = Wage
- $a_1 = 3$ = Kliwon
- $a_1 = 4$ = Legi
- $a_2 = 0$ = Tungle
- $a_2 = 1$ = Haryang
- $a_2 = 2$ = Wurukung
- $a_2 = 3$ = Paniron
- $a_2 = 4$ = Was
- $a_2 = 5$ = Mawulu
- $a_3 = 0$ = Radite/Sunday
- $a_3 = 1$ = Soma/Monday
- $a_3 = 2$ = Anggara/Tuesday
- $a_3 = 3$ = Buda/Wednesday
- $a_3 = 4$ = Respati/Thursday
- $a_3 = 5$ = Sukra/Friday
- $a_3 = 6$ = Tumpak/saniscara/Saturday

By using congruence, the names of the 3 types of Wewaran can be identified by modeling the order number of day x with $0 \le x \le 209$ as follows:

$$a_1 = x \pmod 5;\ a_2 = x \pmod 6;\ a_3 = x \pmod 7$$

Mathematical model for Wuku names: Taking x as the order number of day on Pawukon calendar with $a_1 = x \pmod 5$, the names of Wuku are determined by Wuku number w according to the rule:

$$W = ||x: 7|| \quad (1)$$

with $0 \le w \le 29$ and $|| z ||$ is the biggest integer smaller than or equal to z. Wuku names presented in Table 1 with

Table 1: Wuku names on Pawukon Saka and Pawukon Jawa

w	Wuku names Pawukon Saka Pawukon Jawa
0	Sinta Sinta
1	Landep Landhep
2	Wukir Wukir
3	Krantil Kurantil
4	Tolu Tolu
5	Gumbreg Gumbreg
6	Wariganing wariga Warigalit
7	Wariga Warigagung
8	Julung Julungwangi
9	Julung Sungsang Sungsang
10	Dunulan Galungan
11	Kuninan Kuningan
12	Lankir Langkir
13	Madasidha Madasiya
14	Julung Pujut Julungpujud
15	Pahang Pahang
16	Kuru Wlut Kuruwelut
17	Marakih Marakeh
18	Tambir Tambir
19	Madankunan Madangkungan
20	Maha Tal Maktal
21	WuyaiWuye
22	Manahil Manail
23	Prang Bakat Prangbakat
24	Bala/Mukti Bala
25	Wugu-wugu Wugu
26	Wayang-wayang Wayang
27	Kulawu Kulawu
28	Dukut Dukut
29	Watugunung Watugunung

Pawukon Saka was used, since 732 BC until July 7th 1633 BC while Pawukon Jawa had been used since July 8th 1633 BC up to now.

In 210 days cycle, the combination of three names of the days in Pancawara, Sadwara and Saptawara always occurs leading to possible mistakes in the statement of Wuku names. The mistakes in stating Wuku names bring up a question which is considered as a mathematical problem. However, if we take a closer look, the problem in determining the correct name of Wuku is a mathematical problem that can be solved using the Chinese Remainder Problem/Theorem (CRP/CRT). The use of CRT/CRP will generate a mathematical model to determine the order number of day x as the combination of the three names of Wewaran days.

In this case, the order number of day x fulfill $x \pmod 5 = 3$, $x \pmod 6 = o$ and $x \pmod 7 = 6$. This problem is typically the same by deciding x that fulfill the congruence of $x = 3 \pmod 5 = o \pmod 6 = 6 \pmod 7$. By utilizing the equation given by Kangsheng (1988), the solution of the problem is:

- Remainder: $a_1 = 3$, $a_2 = 0$, $a_3 = 6$
- Modulo: $m_1 = 5$, $m_2 = 6$, $m_3 = 7$
- Modulo product: $m = 5 \times 6 \times 7 = 210$

$$z_1\frac{m}{m_1} = 42, z_2\frac{m}{m_2} = 35, z_3\frac{m}{m_3} = 30$$

Where:

$z_i \times y_i = 1 \pmod{m_i}$

$42y_1 = 1 \pmod 5 \rightarrow 42y_1 + 5_t = 1 \rightarrow y_1 = 3$

$35y_2 = 1 \pmod 6 \rightarrow 35y_2 + 6_t = 1 \rightarrow y_2 = 5$

$30y_3 = 1 \pmod 7 \rightarrow 30y_2 + 7_t = 1 \rightarrow y_3 = 4$

Solution:

$$x = a_1y_1z_1 + a_2y_2z_2 + a_3y_3z_3 \pmod m$$

$$x = 3\times3\times42 + 0\times5\times35 + 6\times4\times30 \pmod{210}$$

$$1098 \pmod{210} = 48$$

Solution of x = 48 determines the 48th day on Pakuwon Saka. In order to determine Wuku names, Eq. 1 is utilized which is w = ||x:7|| = ||48:7|| = ||6.86|| = 6. The 6th order of Wuku is wariganing wariga (not kuningan). It means that Sukamerta Inscription made mistakes in stating the Wuku name.

Mathematical model for order number of day: In equation w = ||x:7||, the number of Wuku w is determined by the order number of day x. Since, the values of y_1, y_2, y_3, z_1, z_2, z_3 and m has been identified according to Sukamerta Inscription and the value is entirely constant, this a mathematical model in the form of simple equation to determine the order number of day x can be obtained which is $x = a_1y_1z_1 + a_2y_2z_2 + a_3y_3z_3 \pmod m$. By substituting the values of y_1, y_2, y_3, z_1, z_2, z_3 and m thus we can get the equation as follows:

$$X = 126\times a_1 + 175\times a_2 + 120\times a_3 \pmod{210} \quad (2)$$

Application (determining Wuku names on inscriptions): Mathematical model 1 and 2 can be utilized in determining Wuku names on various inscriptions. The results are presented in Table 2. There are six inscriptions of which the order number are 1, 3, 4, 15, 25 and 28 whose Wuku names cannot be determined. This happens because there is only one data available in the form of Saptawara days only, hence model 1 and 2 cannot be utilized. Laguna Bay Inscription (order number 4) was found in Philippines.

There are 22 inscriptions that perfectly carved the three names of Wewaran days. Among 22 inscriptions, there are 11 inscriptions that do not have Wuku names carved on. Model 1 and 2 can be used in determining Wuku names of those eleven inscriptions. Moreover, there are 8 inscriptions which are correct in carving their Wuku names while three inscriptions perform some

Table 2: Name of Wuku on inscriptions

	Names of Wewaran days					
Inscription years	Panca wara	Sadwara	Sapta wara	Wuku names	No. of day x	Correct name of Wuku w = ‖x:7‖
Canggal 654 S = 732 AD	-	-	Soma 1	Unidentified	?	?
Manjusrigraha 714 S = 792 AD	Pon1	Was 4	Sukra 5	Unidentified	166	23 Prang Bakat
Pereng 785 S = 863 AD	-	-	Soma 1	Unidentified	?	?
Laguna Bay 822 S = 900 AD	-	-	Soma 1	Unidentified	?	?
Mantyasih I 829 S = 907 AD	U 4	Tu 0	Sa 6	Unidentified	174	24 Bala/Mukti
Kinewu 829 S = 907 AD	Wa 2	Ha 1	Su 5	Unidentified	187	26 Wayang
Sugih Manek 837 S = 915 AD	Po 1	Ma 5	Bu 3	Unidentified	101	14 Julung Pujut
Er Kuwing ?	Ka 3	Ha 1	Wr 4	Unidentified	193	27 Kulawu
Mandiwunga ?	Pon 1	Haryang 1	Wrehaspati 4	Unidentified	151	21 Wuyai
Lintakan 841 S = 919 AD	Umanis 4	Mawulu 5	Soma 1	Unidentified	29	4 Tolu
Harinjing B 843 S =921 AD	U 4	Ha 1	Bu 3	Unidentified	199	28 Dukut
Kinawe 849 S = 927 AD	Wa 2	Wu 2	Wr 4	Unidentified	32	4 Tolu
Sangguran 850 S = 928 AD	Ka 3	Wu 2	Sa 6	Unidentified	188	26 Wayang
Kwak I 905 S = 983 AD	Umanis 4	Wurukum 2	Soma 1	Unidentified	134	19 Madankanan
Lokanatha 946 S = 1024 AD	-	-	Cekra 5	Unidentified	?	?
Cicatih 952 S = 1030 AD	Ka 3	Ha 1	Ra 0	Tambir	33	4 Taulu
Pandak Badung 993 S = 1071 AD	Wa 2	Urukung 2	Wr 4	Gumrg	134	19 Medangkungan
Pakis Wetan 1188 S = 1266 AD	Wa 2	Wa 4	Am 2	Mahatal	142	20 Mahatal
Padang Roco 1208 S = 1286 AD	Wage 2	Mawulu 5	Wrhaspati 4	Madangkungan	137	19 Madangkungan
Singasari 1214 S = 1292 AD	Po 1	Ha 1	Bu 3	Tolu	31	4 Tolu
Kudadu 1216 S = 1294 AD	U 4	Ha 1	Sa 6	Madankanan	139	19 Madangkungan
Sukamerta 1218 S = 1296 AD	Ka 3	Tun 0	ca 6	Kuinan	48	6 Wariganing Wariga
Tuhanaru 1245 S = 1323 AD	U 4	Tun 0	an 2	Krulwut	114	16 Krulwut
Pagaruyung III 1269 S = 1347 AD	-	-	some	unidentified	?	?
Gajah Mada 1273 S = 1351 AD	Po 1	Ha 1	Bu 3	Tolu	31	4 Tolu
Phallus Sukuh1362 S = 1440 AD	Kaliwon 3	Wurukung	Tumpek 6	Wayang	140	26 Wayang
Pamintihan 1395 S = 1473 AD	Ma 4	Ma 5	Su 5	Lankir	89	12 Lankir
Minye Tujoh 781 H =	-	-	sukra 5	Unidentified	?	?
Pakubuwana X 1869 J = 1938 AD	Wage 2	Tungle 0	Senen 1	Prangbakat	162	23 Prangbakat

mistakes in stating their Wuku names. The three inscriptions stated previously are cicatih inscription (No. 16), Pandak Bandung (No. 17) and Sukemarta (No. 22) (Table 2).

The names carved on phallus Sukuh (no. 36) are Pancawara kaliwon ($a_1 = 3$), Saptawara tumpek ($a_3 = 6$) and Wayang Wuku name ($w = 26$). The names of Sadwara days are not written. By utilizing the generated models 1 and 2 we can decide the name of Sadwara day which is Wurukung. This is known after identifying that the number of day $x = 188$.

CONCLUSION

By utilizing CRT, mathematical model for determining Wuku names in Pawukon Saka and Pawukon Jawa can be developed if the three names of Wewaran days are identified. Among 29 analyzed inscriptions using the two models above, the results show that: three inscriptions made mistakes in writing Wuku names, eight inscriptions are correct inwriting Wuku names, the names of Sadwara days of an inscription can be determined, Wuku names of six inscriptions can be determined and Wuku names of eleven inscriptions cannot be determined due to the insufficiency of the data (the data only provide the names of Saptawara days. The names of Pancawara days, Saptawara days and Wuku names are not available).

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