Ethnomathematics: The Early Determining Model of Ramadan and Eid al-Fitr in Hila Maluku

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Abstract. The concept of mathematics comes from the phenomena that exist in the environment, and it has become an essential part of formal education. However, mathematics is still taught in an abstract and rigid language that is disconnected from real-life contexts, particularly those related to society and culture. In short, mathematics education in schools has not integrated cultural context-based mathematics learning. For this reason, this study aims to explore Hila's calendar to determine the first day of Ramadan and Eid al-Fitr using mathematical concepts. This is a qualitative study with an ethnographic approach. Data collection used field observations, interviews, and documentation. The results showed that the first day of Ramadan and Eid al-Fitr can be determined using the modulo and congruence concepts. Therefore, it can be used as teaching material when teaching arithmetic in the school.

Keywords: ethnomathematics · Hila's calender · the first of day Ramadan and Eid al-Fitr

1 Introduction

Numerous occurrences are frequently expressed and explained using mathematical principles [1]. Mathematical explanations exist for the sociocultural phenomenon [2]. Mathematical concepts in cultural objects have existed and been practiced without undergoing a formal educational program [3]. It suggests that the community has been employing the concept of mathematics for a long time without recognizing it, despite the fact that it has not been explicitly taught.

Mathematics education has been dominated by textual and rigid concepts [4]. The students must comprehend abstract mathematical concepts [5]. The material presented is vastly different from what students encountered in their daily life. Consequently, most students view mathematics as frightening and irrelevant [6]. It has implications for student's limited mathematical aptitude, despite the fact that mathematics education in school is intended to prepare students with the skills necessary to solve real-world student problems [7].

Ethnomathematics is a mathematics study that emphasizes the application of mathematical concepts to the activities of a particular society that have been consistently

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practiced [8]. Furthermore, ethnomathematics is interpreted as a form of implementation of mathematical concepts in explaining the cultural phenomena of certain communities [9]. Comprehensively, ethnomathematics is the intersection of three main components, namely 1) culture, 2) mathematics, and 3) mathematical modeling [9]. Thus, it can be stated that ethnomathematics is a very important study because it outlines the relationship between culture, modeling skills, and mathematical concepts. In a more specific context, the study of ethnomathematics is no longer limited to explaining culture using mathematical concepts through mathematical modeling; instead, ethnomathematics has transformed into improving the quality of learning in schools through the integration of ethnomathematics-based learning. Several studies have shown that the use of ethnomathematics contexts contributes positively to mathematics learning in schools, such as improving students' mathematical understanding [10] and increasing students' learning activities and outcomes [11].

Ethnomathematics bridges the gap between mathematical abstraction and contextualization [12]. By examining culture through mathematical principles, it is possible to create relevant and simple-to-understand instructional materials for learning process. According to [13], the use of ethnomathematics-based materials in mathematics education can make it simpler for students to comprehend the notion of using mathematics and its practical application in everyday life.

Previous studies have investigated the concept of culture utilizing ancient dating systems and calendars using ethnomathematics, such as [14], which discusses the modeling of establishing the days of birth and death rites in Yogyakarta based on Pranatamangsa. In addition, [15] examine the Aboge calendar to determine the important days and traditional ceremonies in the palace of Cirebon. Nevertheless, there is no research has attempted to replicate the determination of the first day of Ramadan and Eid al-Fitr using the ancient calendar from Hila, Maluku. Even though the Hila calendar differs from the Aboge calendar used by some Javanese people, the two calendars are not identical [16]. To identify the first day of Ramadan and Eid al-Fitr using the traditional calendar that has been practiced for generations by the people of Hila, Maluku, ethnomathematics experts are interested in studying the culture. It is anticipated that the findings of this study will serve as a guide for the creation of instructional materials that utilize the cultural context of the people of Hila, Maluku, to help the mathematics learning process in schools.

2 Method

This is a qualitative study with an ethnographic approach. This qualitative research investigates the topic in-depth and extensively [17]. Ethnographic methods are utilized to uncover cultural phenomena from multiple vantage points. In addition, an ethnographic method can address and describe study issues in accordance with research objectives [8]. Ethnographic research there are seven components described by researchers, namely language, technological systems, economic systems, social systems, knowledge systems, art, and religion. In this study, researchers focused on two components, namely knowledge systems and religion. This is based on the knowledge of religious leader in determining the first day of Ramadan and Eid al-Fitr in Hila, Maluku.

This study aims to model the first day of Ramadan and Eid al-Fitr based on the calendar used by the people in Hila, Maluku. The design of this study refers to the

ethnomathematics research framework developed by D'Ambrosio [18], which consists of four questions namely 1) *where is it to look?*; 2) *how is it to look*?; 3) *what is it*?; and 4) *what does it mean*?

The description of the research design used in this study is presented in Table 1.

The instrument used in this research is the researcher as the main instrument whose role is to observe and explore important information related to cultural practices that occur in determining the first day of Ramadan and Eid al-Fitr. In addition, there is an interview guideline which is used as the main guide in exploring information from sources related to the ethnomathematics framework used.

Field observations, in-depth interviews, and documentation are used to acquire data. The information was collected from a religious leader in Hila, Maluku. When deciding the first day of Ramadan and Eid al-Fitr, observations were conducted to directly observe the simulation. In the meantime, interview with the religious leader is done to glean facts regarding history, the calendar, and the method for establishing the day. Documentation was conducted in order to collect visual and audio recordings for use in data analysis and triangulation.

Data analysis was conducted in three stages consisting of 1) data reduction, 2) data presentation, and 3) conclusion. Source triangulation was used in this study, specifically 1) the source of the calendar script and 2) the source from an informant.

Table 1. The research design

General Question	Initial Answer	Starting Point	Specific Activity
Where is it to look?	There are mathematical practices in the activities to determine the first day of Ramadan and Eid al-Fitr	Culture	Conducting an interview with an expert to read the calendar
How is it to look?	Investigating aspects to determine the first day of Ramadan and Eid al-Fitr related to mathematics concepts	Alternative thinking	Determining what ideas are contained in making related mathematics concepts
What is it?	Evidence	Philosophical mathematics	Identifying characteristics in the process of determining the first day of Ramadan and Eid al-Fitr
What does it mean?	The significant value of culture and mathematics	Anthropology	Describe mathematical concepts in the process of determining the first day of Ramadan and Eid al-Fitr

3 Result and Discussion

The results showed that to determine the first day of Ramadan and Eid al-Fitr in Hila, Maluku used an ancient calendar that formed a cycle. From using the calendar, a mathematical model was made that can be used to figure out when the first day of Ramadan and Eid al-Fitr will be in the future without having to use the existing calendar and do the calculations by hand.

3.1 The Description of Hila's Calender

The calendar used in Hila consists of eight columns indicating the type of year and twelve rows indicating the type of month. Suppose one wants to specify the first day of Muharram 1443 Hijri (H), then you can pay attention to the third column (the letter Ja) by reading the column of the table from right to left while determining the month of Muharram based on the first row in the table. Therefore, to determine the first day of Muharram 1443, one must pay attention to the confluence between the third column of the first row. At this point, there was information consisting of four lines: in the first line, it read "Muharram of the year of the early Ja", on the second line, it read "Letter Dzal", and on the third line it read "Syahrun Month". And on the fourth row it says the day "Sunday". So, the first day of Muharram 1443 falls on Sunday. Each row and column meeting describe the day, month, and year. Figure 1 shows a picture of the calendar used.

Interviews were conducted with a religious leader in Hila, who was used as an informant in this study, as described in Transcript 1.

Fig. 1. Hila's calender.

Transcript 1

Researcher : Can you explain what components are contained in this calendar?
Informant : So, on this calendar, there are two essential parts. First, at the top (pointing to the calendar), eight columns depict the seven Hijaiyah letters, with the letter Ja repeated. T The letters are as follows: Alif, Ha, the early Ja, Dzal, Da, Ba, Wa, and the last Ja. The column describes the number of years in a cycle.
Researcher : How can it only be eight years in one cycle?
Informant : In this calendar, there is a pattern that once every eight years will return to the way it was in the original year.
Researcher : Why is the number of letters only seven when there are eight years in a cycle?
Informant : In this calendar, the primary reference is the first of Muharram. The first Muharram of the Alif year falls on the first day of the month. In contrast, the year Ha falls on the fifth day, the year of the early Ja falls on the third day, the year of Dzal falls on the seventh day, the year of Da falls on the fourth day, the year of Ba falls on the second day, the year of Wa falls on the sixth day, and the year of the last Ja falls on the third day. Therefore, there are seven Hijaiyah letters, with one letter repeated because it falls on the same day.
Researcher : Okay, sir, we will proceed to the row section. What does this row mean? (pointing to the calendar)
Informant : So, on this calendar, twelve rows describe the number of months in a year.
Researcher : What is the name of the month, sir?
Informant : The name of the month is the same as the name of the month in the Islamic calendar.

Based on the interview results, it can be stated that the calendar used consists of years and months. Eight years repeat in one cycle, and each year consists of twelve months. Suppose the first day of Ramadan 1443 H falls on a Friday, then the first day of Ramadan 1451 H will also fall on a Friday. Likewise, if the second day of Shawwal 1451 H falls on Monday, the second day of Shawwal 1459 H will also fall on the same day, which is Monday. As a result, the day will be the same every eight years on the same date and month.

3.2 Calculations to Determine the First Day of Ramadan and Eid al-Fitr

The calendar is used to determine the first day of Ramadan and Eid al-Fitr by first determining the year and then continuing by looking at the month row. For the first day of Ramadan, use the ninth row, and for Eid al-Fitr, use the tenth row. Here is a simulated example of day determination using a calendar performed by an informant (Fig. 2).

An interview was conducted about the simulation process to determine the first day of Ramadan and Eid al-Fitr. Transcript 2 is an excerpt of the interview between the researcher and informant.

Fig. 2. Simulation to determine the first day of ramadan and eid al-fitr.

Transcript 2

Researcher : What is the process to determine the first day of Ramadan?
Informant : To determine the first day of Ramadan, we have to know what year this is.
Researcher : Suppose this year is 1443 H.
Informant : That means we are in the year of *Ja.*
Researcher : Is this the early or the last?
Informant : We see first the previous year, 1442 H, that is, the year Ha. So the early *Ja* year is the next best thing.
Researcher : Yes, then how do you see the day?
Informant : Notice (*while pointing*) the first column (*from the right*) and the ninth row. There is an inscription on Friday at the intersection of rows and columns.
Researcher : Is it, sir? (*pointing*)
Informant : Yes, of course.
Researcher : What if I want to determine the first day of Ramadan in 1500 H?
Informant : Yes, count from right to left until that year.
Researcher : Is there a pattern, sir?
Informant : The pattern will continue to repeat. According to this calendar, suppose that this year, 1443 H, we fast on Friday; then, in 1451 H, also we fast on Friday. Just add eight.
Researcher : What about the determination of Eid al-Fitr, sir?
Informant : The same way, but with the tenth row, or the month of Shawwal.
Researcher : Is there a pattern if it's related to first day of Ramadan, sir?
Informant : The first day of Shawwal (Eid al-Fitr) falls two days after the first day of Ramadan because we always fast for 29 days.

Based on the interview excerpt above, we can state that modulo can be used with repeated multiplication by eight and residues like 1443 and 1451 if they are written in a congruent modulo-eight form.

A modulo number can be defined as stated in definition 1.

$$\mathrm{a} \bmod (\mathrm{m}) = \mathrm{r} \leftrightarrow \mathrm{a} = \mathrm{mq} + \mathrm{r} \,\mathrm{with}\, 0 \leq \mathrm{r} < \mathrm{m} \tag{1}$$

Example: $1443 \bmod 8 = 3$ and $1451 \bmod 8 = 3$.

We can state that 1443 is congruent to 1451 based on the congruent modulo definition as stated in definition 2.

If a, b and m are all integers with m > 0, a number a and b are congruent if ml(b-a) and it can be written as,

$$a \equiv b \bmod (m) \tag{2}$$

As a result, it is $1443 \equiv 1451 \bmod(8)$.

Based on the calendar used, it can be stated that the first day of Ramadan is studied based on the order of years presented in Table 2.

Thus, the years 1443 H and 1451 H fall on the same day, i.e., Friday, because the year is divided by eight with the remaining three. Using 1647 mod (8) = 7, we can quickly determine the first day of Ramadan in 1647 H. So the first day of Ramadan in that year falls on Monday. Thus, a mathematical model for Ramadan's first day can be stated, namely, a mod (8) = r where a = year and r = the number of days remaining for eight. Using $a \equiv b \bmod (8)$ for the year's same-day model, where a, b = year.

Table 3 is used to determine Eid al-Fitr.

In general, the determination of Eid al-Fitr uses the same model to determine the first day of Ramadan, but what distinguishes it is the day of each year. In particular, based on information from informants, it is stated that Eid al-Fitr falls two days after the first day of Ramadan. As a result, the mathematical model is s = t + 2, where s = Eid al-Fitr (first day of Shawwal) and t = first day of Ramadan.

The determination of religious holidays carried out by the people in Hila is a cultural product that uses the ancient calendar. Several studies have shown that the existence of a calendar can be used as a clue for timing, such as the research by Arisetyawan and Supriadi [19], which uses the Baduy tribal calendar to determine the first day of the month. In addition, Suarjana, Suharta, and Japa [20] found that the concept of repetition of good days on the Balinese calendar has a pattern. Similar research was also conducted by Syahrin, Turmudi, and Puspita [15], which suggests the role of the Aboge calendar in determining religious holidays in Java. Thus, it can be stated that the calendar is a

Table 2. The first day of ramadan by year.

Year (Letters)	Time (divider 8)	Day
Alif	1	Wednesday
Ha	2	Sunday
The early *Ja*	3	Friday
Dzal	4	Tuesday
Da	5	Saturday
Ba	6	Thursday
Wa	7	Monday
The last *Ja*	0	Friday

Table 3. Eid al-fitr (first day of Shawwal) by year.

Year (Letter)	Time (divider 8)	Day
Alif	1	Friday
Ha	2	Tuesday
The early *Ja*	3	Sunday
Dzal	4	Thursday
Da	5	Monday
Ba	6	Saturday
Wa	7	Wednesday
The last *Ja*	0	Sunday

vital medium for determining a particular day based on its pattern using mathematical concepts.

Several studies have shown that students who are used to solving problems using the context that they understand will find them easier to solve [21, 22]. The use of ethnomathematics in learning helps students bridge mathematical concepts with cultural contexts [9, 23]. The ethnomathematics used in mathematics learning employs ethnomodeling. It is based on the fact that ethnomodeling is a process to elaborate on problems related to the actual situation [24]. The problem shown below exemplifies the use of the Hila's calendar to determine the first day of Ramadan and Eid al-Fitr in the future.

This research is expected to contribute to the teaching of mathematics in schools, particularly in simplifying abstract mathematical concepts so that students can be applied to the context of cultural life that students directly experience. In example, when determine the fifth day of Ramadan and the fifth day of the month of Shawwal in the year 1647 H. To solve this problem, students first pay attention to the year in question, 1647 H. Furthermore, students divide 1647 by eight so that seven is obtained as the remainder of the division. Then students will observe the existing calendar and obtain the letter Wa which describes Monday as the first day of Ramadan, while 5 Ramadan falls on Friday. Likewise, for determining the fifth day of the month of Shawwal, students must first determine the first day of the month of Shawwal and then determine the fifth day of the month of Shawwal. The first day of Shawwal in 1647 H was Wednesday, and the fifth day was Sunday.

4 Conclusion

Based on the results and discussion, it can be stated that the first day of Ramadan and Eid al-Fitr use the concepts of modulo and congruence. In addition, to determine Eid al-Fitr, one can use a two-day summation pattern from the first day of Ramadan. This study recommends that teachers use the cultural context of Hila, Maluku, to determine the first day of Ramadan and Eid al-Fitr as teaching material when teaching the concepts of modulo in arithmetic.

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