Ethnomathematics: The use of multiple linear regression

\[ Y = b_1 X_1 + b_2 X_2 + e \]
in traditional house construction Saka Roras in Songan Village

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Abstract: Ethnomathematics may be the connecting bridge between culture and technology and arts. Therefore, the exploration of mathematics values that intersects with cultural anthropology should be significantly conducted. One case containing such issue is the construction of Traditional House of Saka Roras in Bali. Thus, this research aimed to explore the mathematical concept adopted in the construction of such traditional Bale (house) located in Songan Village, Kintamani, Bali. Specifically, this research also aimed to investigate the selection of linear regression coefficient for the saka (pillar) in the Bale. This research applied Embedded Mix-Method Design. Meanwhile, the data collection was conducted by interview, observation and measurement of pillars of 32 Bale Saka Roras. The result of this research revealed that the connection between the width and height of pillars was stated in the formula

\[ Y = 26.3 + 18.2X \]

, where \( X \) acted as stimulus variable. The coefficient value amounted to 18.2 showed that most preceding architects in Songan Village were more likely to use 19 as the coefficient towards the pillar width than the other coefficients such as 17, 20 and 21 as mentioned in book/palm-leaf manuscript entitled Kosala-Kosali. The last but not least, the researchers also figured out that the pillar width depended on the length of the house-owner candidate’s index finger.

1. Introduction

Indonesia is an archipelagic country that becomes home to various tribes. Such variety is apparently followed by cultural diversity. However, the influence of globalization causes several regions’ turmoil due to the confusion of keeping up with the world’s development or preserving the inherited culture. Thus, today’s youth generation may have to face the challenge of how to combine the inherited culture with technology in the purpose of maintaining self-existence in society.

Similar challenge is apparently faced by the Balinese society’s successive generation. Balinese society surely understand that tourist attractiveness is not entirely located in natural beauty, since culture and customs are also the integral part of it. As the consequence, culture and noble values preservation are the absolute obligation. Thus, to embody related obligation, the researchers believe that formal education plays important role. Because by such education, the noble values of culture may be integrated in students’ courses.
One of courses that allows the integration of culture and its noble values is Mathematics. Specifically, the presence of ethnomathematics becomes the solution upon the challenge of cultural preservation and technology and arts mastery. D’Ambrosio [1] states that Ethnomathematics is a form stating the connection between culture and mathematics.

Therefore, further step to perform should be the exploration of Ethnomathematics in Bali as well as its mapping with school’s mathematic concept. Since Ethnomathematics is a new concept or program in education world, there are only a few of works relating to Balinese culture containing such field. This is in line with Powell [2] who states that Ethnomathematics is a relatively new study in the form of coherent one.

A research conducted by Puspadewi [3] revealed that Ethnomathematics found in Balinese woven handicraft shows the use of tessellation in woven handicraft pattern. On the other side, Suryanatha [4] delivers that there are several mathematical concepts contained in Balinese culture, such as Least Common Multiple (LCM) in the calculation of Otonan, circular concept in the construction of Tamas, symmetrical concept in Balinese carving and food paper wrap, and modulo concept in newborn’s name.

The other interesting concept as the result of exploration may be found in the concept of multiple linear regression applied by the architecture of Balinese traditional house. Bale Saka Roras is Balinese traditional building which applies the concept of multiple linear regression in its construction.

Several villages where its residents remain living in Bale Saka Roras are Songan, Pinggan, Belandingan and Terunyan. The four villages are geographically located in the Kaldera of Ancient Batur Mountain, in which most of the residents are the decendants of Bali Mula. Such villages are believed as remotely developed ones which start their development in the last few years.

According to the interview conducted by the researchers with the aging residents of Songan Village, the village’s residents had to face the difficulty of obtaining equipment for house construction. On the other hand, most of Bale Saka Roras were constructed approximately 30-100 years ago. Based on such fact, the researchers aimed to investigate the accuracy of measurement by the architects of Bale Saka Roras in Songan Village.

2. Method

This research was conducted in March to April 2017 in Songan Village, Kintamani Sub-District, Bangli Regency, Bali by using qualitative as well as quantitative methods (mixed method). More importantly, Embedded Mixed Method was also used in this research [5].

![Figure 1. Design of Embedded Mixed Method.](image-url)

Referring to such type, the qualitative or quantitative data was collected before collectively analyzed and interpreted by the researchers. In the stage of Qualitative, the researchers conducted an interview with two architects of traditional house and one figure who had particular knowledge in traditional house. The researchers then paired the information obtained from the interviewees with the proposed theories in several related literatures. The researchers also performed the same activity with the chosen residents of Bale Saka Roras or specific people who had comprehension in the history of such traditional building. Subsequently, the researchers quantitatively collected the data on the pillars’ width and length by measurement. There were 32 Bale Saka Roras’ pillars measured.
3. Result
Bale *Saka Roras* is Balinese traditional house. In its construction, the architects greatly considered the aspect of harmony. Therefore, the division of spaces (*Mandala*) in its construction was inspired by the *Tri Hita Karana* that teaches about three factors of harmony. *Tri Hita Karana* is a commandment regulating the relationship between human and God, among humans, and between human and environment.

The dimension of time (*kala*) also needed to be considered in the construction of Balinese traditional house. Widana [6] writes that according to Balinese society’s perspective, each time has the aspect of merit and demerit due to natural movement (*Macrocosms*). Such movement, in case of measuring traditional building in Bali, always refers to the measurement of the house owner’s body part size, in the hope of the space compliance between the building and its owner [6].

As the foothold of the implementation of time dimension and the harmony of concept, the architects referred to the book/palm-leaf manuscript entitled *AstaKosala-Kosali*. *AstaKosali* is a name of palm-leaf manuscript describing the measurement of house construction, while *Asta Kosala* explains the measurement of tower or high building, media, bade, coffin [7]. By referring to regulations contained in *AstaKosali*, the measurement of *Bale Saka Roras* may be considered to such an extent, which depended on the body posture of man (head of family) who would live in the house. *Bale Saka Roras* is a house (*Bale*) with 12 (*Roras*) pillars (*saka*). The form of *Bale Saka Roras* may be described in the following figure:

![Figure 2. Form of Bale Saka Roras.](image)

One of interesting things on *Bale Saka Roras* wasthe relationship between its pillar measurement and Mathematics. The pillars measurement is extensively specified in *Asta Kosali*. Theoretically, the followings are several pillars measurement that may be applied in the construction of house or worship place [7].

1. Length of 21 *rahi maurip anyari kacing*, namely *Bhatara Asih* (Main)
2. Length of 21 *rahi maurip aguli madu*, namely *Bhatara Asih* (Medium)
3. Length of 20 *rahi maurip aguli linjong*, namely *Prabu Nyakra Negara* (Medium)
4. Length of 19 *rahi maurip anyari linjong*, namely *Mitra Asih* (Main)
5. Length of 19 *rahi maurip anyari linjong*, namely *Istri Asih* (Medium)
6. Length of 25 *rahi maurip anyari kacing*, namely *Prabu Murti Jinem*
7. Length of 23 *rahi maurip anyari kacing*, namely *Tri Gegana*
8. Length of 23 *rahi maurip aguli*, namely *Sang Hyang Gana Tunggal.*
9. Length of 20 *rahi maurip aguli tujuh*, namely *Kusuma Mahadevi.*
10. Length of 19 *rahi maurip acaping* (*atelek*), namely *Sang Hyang Nawagana.*

Several Balinese terms used are *rahi* (*a rai*), *a guli, a nyari* that are the measurements of house-owner candidate’s body part, which is more popular as Anthropometry. The followings are the measurement of *rahi, nyari, and guli* [8].
Figure 3. Measurement of a nyari, a rahi, a guli.

The other attraction that may be explored from the above mentioned measurement was the concept of Linear Regression. If there is one variable that acts as stimulus, such condition may be called as the general form of $Y = A + BX$ and as multiple linear regression when the stimulus variables are two or more. Two stimulus variables may be formed in $Y = A + B_1X_1 + B_2X_2$.

In relation with the specification of pillar measurement and Bale Saka Roras construction, the measurement of the house-owner candidate’s body part acted as the variable. For example, “The Length of 19 Rai Maurip a nyari Linjong” may be written in the following mathematic model:

$$Y = 0 + 19X_1 + 1X_2 \text{ atau } Y = 19X_1 + X_2$$

with

- $Y$ = Length/Height of Pillar
- $X_1$ = a Rai (Length of house-owner candidate’s index finger)
- $X_2$ = a nyari linjong (Width of house-owner candidate’s middle finger)

Such function was only an example. There were actually more than 10 other functions with different coefficients and stimulus variables. Each function or specification had its own strength and weakness as well as relationship with the house-owner candidate’s social stratification. Therefore, in spite of the same location, the researchers thought that it was possible that one’s house had different measurement to another, in this case, the case study of the Bale Saka Roras measurement in Songan Village, Kintamanai Sub-District, Bangli Regency, Bali.

Songan Village is one of villages located in the inner of Ancient Batur Mountain Caldera. The residents in Songan Village are the mix of Bali Mula and Bali Arya society. Such cultural assimilation allowed the existence of different perception in the measurement of traditional house construction. Besides, considering the sanctity of the measurement and its impact towards the life of the house-owner candidate or architect in-charge, the measurement must be performed under strict specification. This issue became the other factor causing the difference of measurement between one house to another.

The limitation of construction equipment such as saw, ax, measuring tool and pencil experienced by the architects in Songan Village in 1930s became the factor that inhibited the accuracy of measurement amounted up to 1 millimeter, eventhough the architects were accustomed to be highly accurate and persistent in constructing ideal houses.

In order to figure out the most-applied measurement by preceding architects in Songan Village in constructing Bale Saka Roras, the researchers measured 32 Bale Saka Roras. Specifically, the researchers measured the width and height of pillars. Since it was difficult to figure out the measurement of pangurip due to its unification with pillar’s length/height, the researchers subtracted the measured pillar with 3 cm (average measurement of a guli) as the most-applied pangurip.

The combination of measurement method and interview with the resident or specific people having the knowledge related to the history of traditional house construction provided an advantageous information to the researchers. Based on the interview, the researchers found out that there were 4 house (Bale), in which in its construction process, did not fulfill the house-owner candidate’s expectation and material availability. Thus, the researchers decided to exclude those houses from the data analysis. In other words, there were only 28 houses to analyze. From 28 houses, the researcher figured out the relationship between the pillar’s width and height in the form of the following regression equation:
With $Y$ stated the pillar’s height and $X$ stated the pillar’s width. By referring to the equation (2), the researchers conclude that most of preceding architects presumably used 19 as the coefficient towards the measurement result of house-owner candidate’s body part.

4. Discussion

The researchers’ inquisitiveness on the applied coefficients (17, 19, 20, 21, 23, or 25) was based on the numerous Bali Mula society’s distinctive cultures. The relationship between the amount of coefficient and social stratification of the house owners also became the other significant reason. Therefore, the researchers believed that it was necessary to figure out the coefficient used by most of Bale Saka Roras in Songan Village. The finding on coefficient of 19 tended to refer to the geographic condition of Songan Village (in the mountain). This kind of location then caused them to construct shorter house’ height since this may prevent them from the cold air. The use of Saka Roras as the main house by most of Bali Mula society in Songan Village indicated that they are not the King’s descendants. This was in line with the genealogical information stating that their ancestors was Mpu Kamareka (a poet). Furthermore, the size of a rai in the pillars’ width may be used to figure out the body anatomy of the Bali Mula society’s ancestors, such as the body’s height. Such height may be figured out by firstly finding the relationship between index finger’s length (a rai) and body’s height. The researchers may also predict the other body’s anatomies such as head diameter and lips circumference. The former was predicted by measuring the width of front door, while the latter was by measuring the width of traditional stove. Thus, by figuring out the sizes of parts of inherited Bale Saka Roras, the researchers were possibly able to reveal the characteristics of the tribe’s ancestors, at least the four generations above. This would be critical information, since the photographs of such traditional building inheritance are not available.

References

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