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Ethnomathematics: A mathematical exploration on the layout of *tui gubuk* and the architecture of *Segenter* Traditional House

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ABSTRACT: Mathematics is found in many activities of traditional culture. However, many perceive that mathematics is culture-free. Based on the occurring phenomenon, ethnomathematics study is made as the connector between mathematics and culture. The presence of ethnomathematics provides many opportunities to discover unique mathematical ideas exist in the traditional culture. This research aims to explore mathematical ideas in the layout of *tui gubuk* and the architecture of *Segenter* traditional house that can be made as mathematics learning sources. This study was a qualitative research with ethnographic method. This study was conducted in the traditional village of Segenter, Sukadana Village, Bayan District. Data were collected through an observation and interviews with Adat figures, cultural anthropologists, and traditional leaders who have the knowledge of the customs and culture of Bayan people, which consisted of three informants. Research results indicate that there are mathematical ideas in the layout of tui gubuk and the architecture of Segenter traditional house that can be made as the learning sources of mathematics and can be developed in mathematics learning, especially in materials of set and geometry, both geometry of space and flat geometry.
Keywords: Mathematical ideas; Tui gubuk layout; Traditional house; House architecture

Etnomatematika: Eksplorasi matematika pada tata ruang tui gubuk dan arsitektur rumah adat Segenter

ABSTRAK: Matematika ditemukan dalam aktivitas budaya tradisi. Namun banyak yang menganggap bahwa matematika bebas budaya. Berdasarkan fenomena yang terjadi, maka kajian etnomatematika dijadikan sebagai penghubung antara matematika dan budaya. Kehadiran etnomatematika memberikan banyak peluang untuk mengkaji ide-ide matematika yang terdapat dalam budaya tradisi yang bersifat unik. Tujuan dari penelitian ini adalah mengeksplorasi ide-ide matematika pada tata ruang *tui gubuk* dan arsitektur rumah adat Segenter yang dapat dijadikan sumber belajar matematika. Penelitian ini merupakan penelitian kualitatif dengan metode etnografi. Penelitian dilakukan di perkampungan tradisional Segenter Desa Sukadana Kecamatan Bayan. Pengumpulan data dilakukan dengan cara observasi dan wawancara dengan tokoh-tokoh adat, budayawan serta penghulu adat yang memahami adat istiadat dan budaya masyarakat Bayan yang terdiri dari 3 orang informan. Hasil penelitian menunjukkan bahwa terdapat ide-ide matematika yang terdapat pada tata ruang *tui gubuk* dan arsitektur rumah adat Segenter yang dapat dijadikan sebagai sumber belajar matematika dan dapat dikembangkan dalam pembelajaran matematika terutama pada materi himpunan dan materi geometri baik geometri datar dan geometri ruang.
Kata kunci : Ide-ide matematika; Tata Ruang Tui Gubuk; Rumah tradisional; Arsitektur rumah

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INTRODUCTION

Mathematics is inseparable from our daily lives, mathematics emerges explicitly, even without being realized. At least, mathematics can be found in counting activities in numerical forms (D'Ambrosio & Rosa, 2017). At present, people are completely depending on mathematics as the result of science and technology (Kline, 1990). Mathematics has been developed by traditional people in their lives, traditional people in question are people who are relatively unaffected by the progress of modern technology. Mathematics knowledge is acquired from the exploration towards community actions in cultural activities (Bishop, 2014). Mathematics can be identified in various cultural activities in a group of both traditional and modern people (Rosa & Orey, 2015). It means that ethnomathematics refers to mathematical concepts found in cultural activities and it is acknowledged that all cultures develop unique methods to understand the reality of their people (Rosa & Orey, 2013).

Mathematics is a complete component of all cultural contexts and the meaning of all cultural contexts is affected by the interpretation of individuals within the culture. To utilize all cultural activities exist in the community, students must be faced against various experiences and cultural sources they encounter. Schools can facilitate students to learn about their cultures and the culture of others through learning activities that show the correlation between culture and mathematics (d'Entremont, 2015). In a class, teachers should pay their attention towards students' knowledge acquired from the environment on cultural activities (Zeichner, 1996). In conducting this action, teachers also consider ethnical identities and culture of students to be capable of understanding and developing mathematical potentials of students established socially and culturally (Banks, 1991; Lee, 2003).

Most people perceive that there is a gap between mathematics and culture, mathematics is a knowledge that is free from value and culture (Bishop, 1988). Mathematics is understood as the product of culture that developed as the result of diverse community activities (Bishop, 1988b). Based on the occurring phenomenon, ethnomathematics studies are made as the intermediary between mathematics and culture. Ethnomathematics is mathematics that is practiced by cultural groups (D'Ambrosio, 1985b). In acquiring mathematical knowledge, a group of culture has their own approaches (Gilmer, 1995). Ethnomathematics is the study on mathematical ideas retrieved from cultural activities, not only at the level of implicit idea compositions, but are also practiced explicitly in daily activities by that cultural group (Ascher & D'Ambrosio, 2012). Ethnomathematics is a part of the exploration of ideas, activities, and concepts of mathematics of the social group (Knijnik, 2002). Ethnomathematics is an innovative learning conducted through cultural approaches (Khalimah et al., 2017). Therefore, it can be said that ethnomathematics involves students to build their mathematical knowledge from the understanding towards their culture.

Ethnomathematics was initially developed as the means to express the mathematics used by community outside the academic mathematics: mathematics is found in traditional culture (Powell & Frankenstein, 1997). As a broader study that is related to education, culture, and politics, growing ideas produce a broader view regarding ethnomathematics (Powell & Frankenstein, 1997). Therefore, there is no simple of such a term, but the collective perspective of many authors regarding the subject provides an adequate comprehension regarding its scope and purpose (Weldeana, 2016). Then, ethnomathematics attempts to use cultural anthropology and cognitive theory for a specific mathematical implementation of a cultural group that is identifiable from the effort to overcome the mathematics education regarding procedural solutions found in academic mathematics (D'Ambrosio, 1985a).

The color of a culture will always be associated with various aspects, including the origin, cosmological thinking, and beliefs that will eventually give birth to a cultural behavior (Fatrurrahman, 2016). Referred to as Gumi Sasak, Lombok Island with its history, origin and cosmological thinking transformed through the history of journey, later built a settlement pattern in exploring its new life. In every space, Sasak people try to build cosmological harmony in starting and determining their self-orientation, where they can live in safety and comfortably. Sasak people live the space with the concept of *paer*, which means homeland. Therefore, it is not surprising that there are still traditional villages exist until present. One of which is the Segenter Adat village located in Bayan District. The layout and architecture of the Segenter traditional village are on the customary land in which the ownership is communal, where the individual right is only a hereditary usufruct. Segenter people build their settlement or village on a square plot of customary land surrounded by *kuta* (village border fence). People activities in building their settlement or village are inseparable from mathematical calculations called as *berekeng*.

The architecture of Segenter traditional house is not much different from the concept of Austronesian traditional house, which consists of heaps, beam pillars, and roof. The Segenter traditional house is called by the term *bale mengina* (female house), in reference to the *Gumi Bayan Gumi Nine* concept of Bayan people. Besides houses as the living residence, there are non-residential buildings, namely *berugaq* and the warehouse for agricultural products. *Berugaq* is a resting place that also works to welcome guests, while the warehouse for agricultural products consist of three types, namely *geleng*, *pundutan*, and *sambi*.

In view of the above, the layout of *tui gubuk* and the architectural form of Segenter traditional house can provide new knowledge and ideas that can be implemented in mathematics learning as the purpose of this study which is to explore mathematical ideas in the layout of *tui gubuk* and the architecture of Segenter traditional house that can be made as the learning sources of mathematics.

METHOD

This study was a qualitative research with ethnographic method. Ethnographic method is a study towards social interactions and community behaviors, which involves participations and a time-specific observation while interprets data collected during the study (Berry, 2011; Denzin & Lincoln, 2011; Reeves et al., 2008). The purpose of the qualitative research with ethnographic method is to understand the way of life of others from the actual perspective or naturally (Spradley, 2016). This ethnographic method is chosen because it is consistent with the aim of ethnomathematics studies, in which ethnomathematics studies an idea, method, and technique in cultural activities from the community's perspective as the member of such a culture (Ascher & D'Ambrosio, 2012). Data collecting was conducted through an observation or field study and interviews with Mr. Moch. Yamin as a cultural anthropologist of Sasak, Mr. Raden Gedarip as a cultural anthropologist of Sasak Bayan, and Amaq Riajim as a Bayan traditional leader.

A comprehensive information was acquired from the interviewees on how Segenter people build their settlement. The collected data were analyzed through content and taxonomy analyses to discover mathematical ideas exist in the layout and architecture of Segenter traditional house.

RESULT AND DISCUSSION

Segenter people build their settlement or village on a square plot of customary land surrounded by *kuta* (village border fence). Kuta works as a border and defense system. Castor trees are made as the kuta that are also be functioned as a medicinal plant, and the provider for the requisite of a customary ceremony, i.e., *buang awu* ritual.

For Bayan people, including Segenter, the first consideration in building their village is Mount Rinjani. Mount Rinjani is made as the center of orientation for the layout design in each opening of a new settlement.

As a layout, the entire Segenter village consist of three domains, namely:

1. *Tanak adat tui gubuk*: all lands or areas made as the place to construct buildings with an approximately 3 hectares of square-shaped area. *Tui gubuk* has two lanes with a width of ± 3 meters, namely one lane in the middle stretching from east to west and one lane in the middle stretching from north to south, thus, tui gubuk is divided into four equal parts. *Tui gubuk* has four main doors located on the south, north, east, and west, however, these doors have a similar function, namely as the in and out access of local people.
2. *Tanak adat duwe gubuk*: the area outside the *kuta* (village border fence). The area is ± 6 hectares surrounding the *tui gubuk*. *Tanak adat duwe gubuk* is made as the reserve for village extension if such a condition is necessary. *Tanak adat duwe gubuk* is usually cultivated in turns by the people with a rule that the yields are divided by two, one part for the cultivator and the other part is handed to the customary institution.
3. *Tanak pecatu adat*; the area designated as the cultivation land for each *pemekel* and acting Adat hamlet leader with his subordinates with an area of ± 10 hectares. *Tanak pecatu adat* surrounds *tui gubuk* and *tanak adat duwe gubuk*.

The layout of the village or *tui gubuk Segenter* is located in the center of *tanak adat duwe gubuk* and *tanak pecatu adat* as presented in Figure 1 as follows.

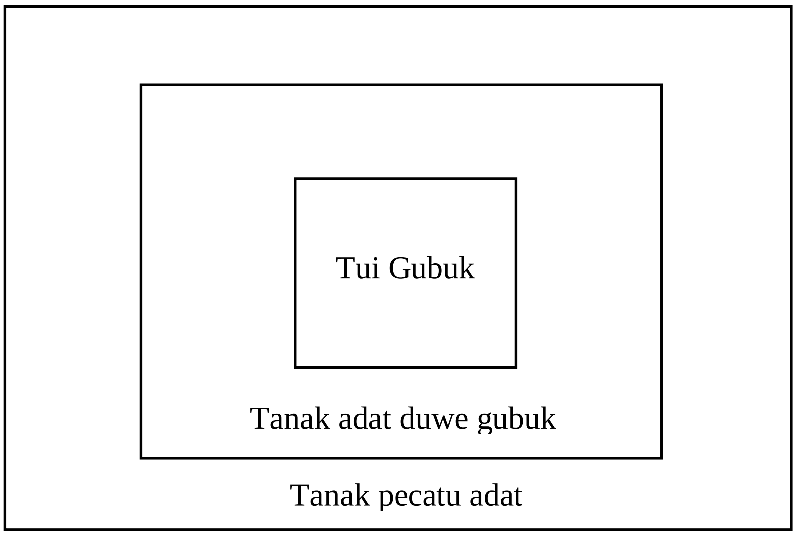
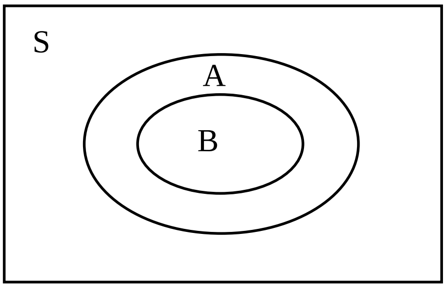


Figure 1. The village layout of Segenter

The shape and concept of village layout or *tui gubuk Segenter* can be used in mathematics learning, namely in the subset topic. Sets A and B are provided. If each member of A is the member of B, thus, it can be said that A is the subset of B or B contains A and symbolized with $A \subset B$. So, $A \subset B$ if and only if $x \subset A$, $x \subset B$ if there is a member of A that is not the member of B, making A as the non subset of B, symbolized with $A \not\subset B$.



As the settlement area of Segenter people, *Tanak adat tui gubuk* is divided into four equal parts with two lanes or alleys as the in and out access for the local people. The details can be seen in Figure 2 as follows.

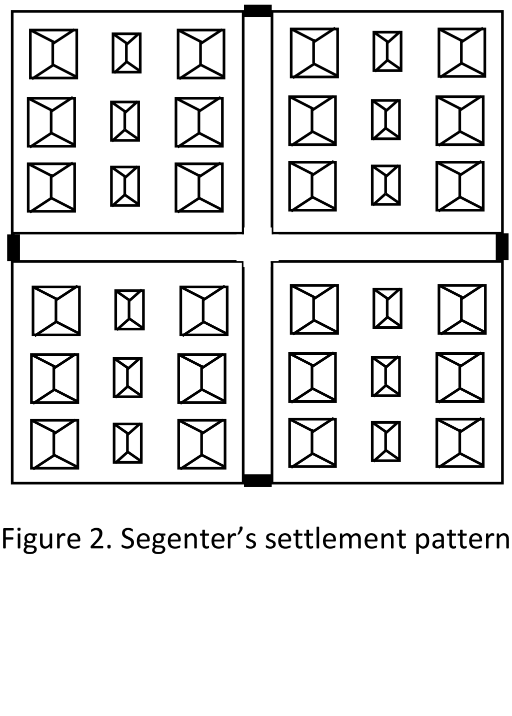
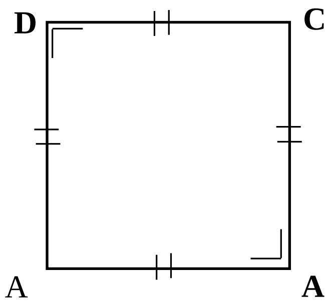


Figure 2. Segenter's settlement pattern

The settlement pattern of Segenter people is lined up neatly forming four large groups called by the term *bantar*, each *bantar* stretches from south to north and consists of several rows of building. There are one house on the east and one house on the west in each row that flanks a *berugak* or *sekenem*. A *sekenem* building is the joint property two traditional houses if those houses are adjacent to each other on the west and east of the *sekenem*. The Segenter's settlement pattern can be made as the initial step to learn mathematics, especially in the topics on geometry, namely square and rectangle plane figures. Plane figure is a geometric figure in which all of its parts are on a flat surface. It is also called as two-dimensional figure.

Square

Square is a plane figure bounded by four equal sides and four right angles.

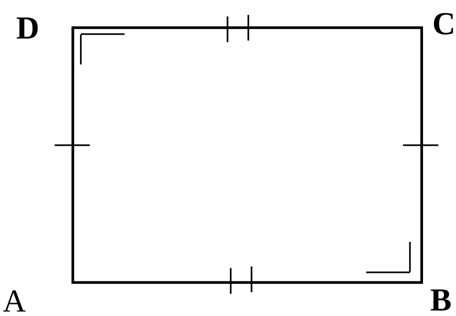


Properties:

1. All four sides of a square are equal (AB = BC = CD = DA)
2. Two adjacent sides are equal in length (AB // CD and AD // BC)
3. Four equal angles (90^o) (∠A, ∠B, ∠C, ∠D)
4. Two diagonals intersect each other at right angles (AC = BD , AC ⊥ BD)
5. Four fold symmetry
   a. D→A and C→B
   b. D→B
   c. D→C and A→ B
   d. C→A
6. Four rotational symmetry (A → D→C→D→A)
7. Perimeter = 4s
8. Area = s^2

Rectangle

Rectangle is a plane figure bounded by two parallel sides and four right angles.



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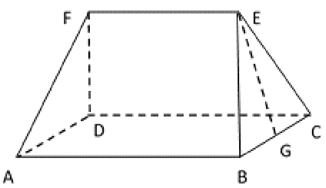
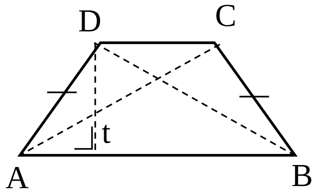
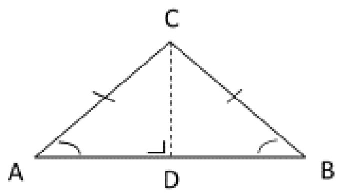
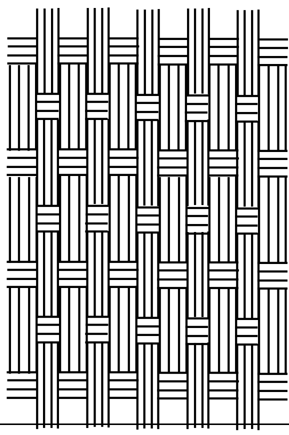
Properties:
1. Four sides, the opposite sides are equal in length (AB = CD and AD = BC)
2. Two parallel sides (AB // CD and AD//BC)
3. Four right angles (90^o) (∠A, ∠B, ∠C, ∠D)
4. Two intersecting diagonals and the same length (AC = BD)
5. Two fold symmetry
   a. D→A and C→B
   b. D→ C and A→B)
6. Two rotational symmetry
   a. A→C and B→D
   b. A→A and B→B)
7. Perimeter = *2(l + w)*
8. Area = *l x w*

The main building of Segenter traditional house is divided into two parts, namely the inner space (*dalem bale*) and the transition room (*sirap*). *Dalem bale* consists of *paon* (kitchen), *kelepok* (storage in the house), *amben belek* (big bunk), and *inan bale* (master room). *Sirap* (terrace) is the outermost part of the traditional house functioned as the transition room from the yard into the *dalem bale*. Besides, *sirap* is also functioned as the resting place, the bed for adult sons or parents in the evening, and the place to store agricultural equipment.

Representation	Object	Mathematical Concept
The house roof is saddle-shaped or pyramid-shaped. The roof element with crabgrass as the material is the most noticeable element seen from the outside. One roof requires 100 ties of crabgrass with a tie diameter of 40 cm. 	House Roof	In determining the quantity of materials required in creating the roof, arithmetic concept is used, namely the number operation. Roof shape  Two sides are isosceles triangles, so: The area of triangle-shaped roof: L = 2(1/2 x base x height) Two sides are trapezoidal-shaped, so: The area of trapezoidal-shaped roof L = 2((AB + EF)/2 x height)

Representation	Object	Mathematical Concept
The front and rear sides of the roof are trapezoidal-shaped. The roof of the house is made low with a fairly steep slope aimed for the rainwater to fall smoothly. 	The front and rear views of the roof	 Properties: 1. A pair of sides are the same length (AD = BC) 2. A pair of parallel opposite sides (AB // CD) 3. Two pairs of angles whose sum is 180^o (∠A + ∠D and ∠B + ∠C = 180^o) 4. Two pairs of equal angles (∠A = ∠B and ∠C = ∠D) 5. Two diagonals that intersect and have the same length 6. t = trapezoid's height 7. Parameter = AB + BC + AD + CD 8. Area = ½ t (AB + DC)
The roof is in the shape of isosceles triangle from the side 	The side view of the roof	 Parameter = AB + AC + BC Area = ½ AB x CD
The wall is a woven bamboo material with the shape and size as the height of the house which is attached to a wooden column by perforating the wood for the entry of a woven bamboo. This is done so the bamboo can stand upright and strong. The woven bamboo wall consists of three options which are woven vertically and horizontally.	House wall	

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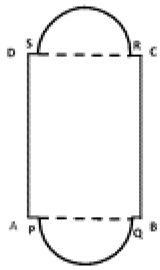
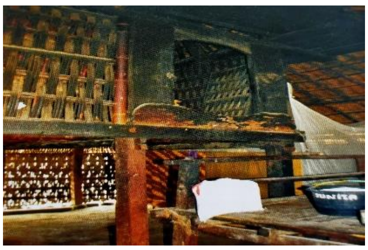
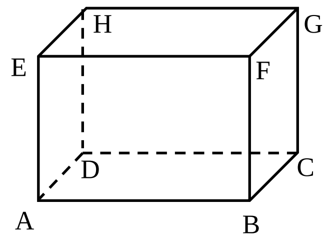
Representation	Object	Mathematical Concept
The wall is made low as high as the owner's *depa*. 		If seen from the picture above, the webbing is formed from the link-up of vertical and horizontal lines. A line can be represented as a collection of points. The line is endless and has no beginning which means the line can be extended in both directions. A line can be denoted by lowercase letters, for example line *k*, line *l*, line *m*, line *n*, and so on. Besides the lines, the webbing on the wall also consists of flat rectangles.
On the walls there are no windows, only one entrance made of wood and woven bamboo with a sliding door system. The door is made low so that people who enter and leave will bow down with the philosophy of mutual respect. The *inan bale* wall is also a wall made of woven bamboo. 	House door	 The perimeter of rectangle = *2 (l + w) – 2 x diameter* = 2 (AB + AD) – (2 PQ) Circumference = 2πr = πd Combined circumference = 2 (AB + AD) – (2 PQ)) + πPQ The area of rectangle = l x w

Representation	Object	Mathematical Concept
		= AB x AD The area of circle = πr2 $= \pi \left(\frac{1}{2}d\right)^2$ $= \pi \left(\frac{1}{2}PQ\right)^2$ The combined area $= (AB \times AD) + \pi \left(\frac{1}{2}PQ\right)^2$
There is a room above in the middle of the room parallel to the *sembako* (ridge), built with six pillars with a height of 1.5 m above the floor of the house in the form of a cuboid called *inan bale*. *Inan bale* functioned as a place of worship (get closer to God) and to put offerings for ancestral spirits. In addition, the *inan bale* is used as a place to put *temberasan* (a rice storage barrel) and a place to store valuables. 	*Inan bale*	Cuboid  Cuboid's properties: 1. Six sides consisting of three pairs of equal sides (ABCD with EFGH, EFGH with ABCD, ADHE with BCGF) 2. 12 edges consisting of three groups of equal and parallel edges AB = CD = EF = GH = length BC = FG = AD = EH = width AE = BF = CG = DH = height 3. Eight vertices (∠A, ∠B, ∠C, ∠D, ∠E, ∠F, ∠G, ∠H) 4. 12 diagonal faces (AC, BD, EG, HF, AF, EB, CH, DG, AH, ED, BG, CF) 5. Four equal diagonal spaces (AG, BH, CE, DF)

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Representation	Object	Mathematical Concept
		6. Volume = *l x w x h* 7. Area = 2 x { (*l x w*) + (*l x h*) + (*w x h*) } 8. Parameter = 4 x (*l + w + h*)

The results of the mathematical exploration on the layout of *tui gubuk* and the architecture of Segenter traditional house provide a lot of new knowledge in which the local culture context can be made as the learning source in understanding mathematical concepts contextually. Contextually, mathematics learning is an exploration process of problem situations, pattern visualizations, and model developments that produce mathematical concepts. Contextual problems are not only perceived as the conceptual application in mathematics learning or as the instrument to conclude the learning process, but are also made as the learning source of mathematics (Zulkardi, 2002). The conceptualization of mathematics indicates the correlation between the existing knowledge and the adjustment of new knowledge. Symbols play the inseparable role in the integration of new knowledge. The main function of symbols is communication (Skemp, 1987).

In mathematics learning, there is a measure that can be done to make the teaching is more effective, namely by considering social and cultural issues (Bishop, 2014). Therefore, we can perceive multicultural education as a part of the blueprint for educational activities intended for all students. Multicultural mathematics is the implementation of mathematical ideas on problems faced by people in daily activities (Zaslavsky, 1991). Culture encompasses all activities associated with art, history, music, philosophy, and religions (D'Ambrosio & D'Ambrusio, 2013). Therefore, teachers use this cultural term to help students in mapping the learning before the new learning is began (D'Ambrosio & D'Ambrusio, 2013). Ethnomathematics approach involves students in building mathematics knowledge they discover in their own cultures. This approach is a constructivism approach that is capable of reducing students' anxiety in learning mathematics (Bada & Olusegun, 2015). As elaborated by the results of studies above, it can be concluded that mathematics knowledge can be developed by integrating culture as the learning source, and involving the initial knowledge of students acquired from the environment in daily activities.

CONCLUSION

The layout of *tui gubuk* and the architecture of Segenter traditional house can be made as the learning source of mathematics, in which the layout and architecture of Segenter traditional house contain mathematical ideas and geometric shapes as the composer. In general, the village/settlement layout of Sasak people is square, including the shape of Segenter's *tui gubuk*. *Tui gubuk* is square surrounded by *kuta* as the village border, *tui gubuk* is surrounded by the area reserved for expansions called by the term *tanak adat duwe gubuk* with an area of approximately six hectares. *Tanak adat duwe gubuk* is surrounded by an area of 10 hectares made as the cultivation area for *pemekel* and the acting Adat hamlet leader with the subordinates, which is called as *tanak pecatu* adat. If seen from its layout, the Segenter's *tui gubuk* forms mathematical patterns, namely subsets.

The architecture of Segenter traditional house is called by the term of *bale mangina*, which is saddle-shaped or pyramidal. *Bale mangina* consists of two parts, namely the inner space (*dalem bale*) and the transition room (*sirap*). There is a room above in the middle of *dalem bale* parallel to *sembako* (ridge), built with six pillars with a height of 1.5 m above the floor of the house in the form of a cuboid called *inan bale. Inan bale* is functioned as a place of worship (get closer to God) and to put offerings for ancestral spirits. In addition, the *inan bale* is used as a place to put *temberasan* (a rice storage barrel) and a place to store valuables. Besides the shape of the roof, Segenter traditional house is also equipped with fences and doors in the shape of plane figures. Therefore, the layout of tui gubuk and the architecture of Segenter traditional house can be made as the learning source of mathematics contextually.

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