AKSIOMA: Jurnal Program Studi Pendidikan Matematika
Volume 14, No. 3, 2025, 815–827

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

DOI: https://doi.org/10.24127/ajpm.v14i3.12845

THE CONCEPT OF ALGEBRAIC AND GEOMETRIC FUNCTIONS IN TRADITIONAL LOMBOK *BALE* SADE: AN ETHNOMATHEMATICS STUDY

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Received 28 May 2025; Received in revised form 19 July 2025; Accepted 01 September 2025

Abstract

This study aims to explore the application of the concepts of algebraic functions and geometry in the traditional architecture of Bale Sade, a traditional house of the Sasak people in Lombok, through an ethnomathematics approach. Although previous studies have highlighted geometric aspects in Sasak arts and crafts, in-depth studies of the application of algebraic and geometric principles in traditional building structures are limited. This research uses a qualitative approach with descriptive methods, through field observations in Rembitan Village, Pujut Subdistrict, interviews with several resource persons, TA (Traditional Leaders), and PW (Tour Guides), and documentation in Rembitan Village, Pujut Subdistrict, Central Lombok. Data analysis refers to the Miles and Huberman model which includes collecting, reducing, presenting data, and drawing conclusions. The results show that the structure of Bale Sade reflects mathematical principles such as symmetry, proportion, and geometric balance, as well as the application of algebra in calculating dimensions and efficient use of materials. In addition to functioning as a residence, Bale Sade reflects local wisdom that is closely related to cultural and environmental values. While previous studies have highlighted geometric aspects in the arts and crafts of the Sasak people, this study also makes an in-depth contribution to the application of algebraic and geometric principles in traditional building structures. This research recommends further studies that highlight the resilience of traditional architecture to climate change and the potential integration of modern technology in design without losing cultural values.

***Keywords**: Bale Sade, Ethnomathematics, Function algebra, Geometry, Sasak traditional architecture*

Abstrak

Penelitian ini bertujuan untuk mengeksplorasi penerapan konsep fungsi aljabar dan geometri dalam arsitektur tradisional *Bale* Sade, rumah adat masyarakat Sasak di Lombok, melalui pendekatan etnomatematika. Meskipun kajian sebelumnya telah menyoroti aspek geometris dalam seni dan kerajinan masyarakat Sasak, kajian mendalam terhadap penerapan prinsip aljabar dan geometri dalam struktur bangunan tradisional masih terbatas. Penelitian ini menggunakan pendekatan kualitatif dengan metode deskriptif, melalui observasi lapangan di Desa Rembitan, Kecamatan Pujut, wawancara dengan beberapa narasumber, TA (Tokoh Adat), dan PW (Pemandu Wisata), dan dokumentasi di Desa Rembitan, Kecamatan Pujut, Lombok Tengah. Analisis data mengacu pada model Miles dan Huberman yang mencakup pengumpulan, reduksi, penyajian data, dan penarikan kesimpulan. Hasil penelitian menunjukkan bahwa struktur *Bale* Sade mencerminkan prinsip-prinsip matematis seperti simetri, proporsi, dan keseimbangan geometris, serta penerapan aljabar dalam penghitungan dimensi dan efisiensi penggunaan material. Selain berfungsi sebagai tempat tinggal, *Bale* Sade mencerminkan kearifan lokal yang erat kaitannya dengan nilai-nilai budaya dan lingkungan. kajian sebelumnya telah menyoroti aspek geometris dalam seni dan kerajinan masyarakat Sasak, kajian ini juga memberikan kontribusi mendalam terhadap penerapan prinsip aljabar dan geometri dalam struktur bangunan tradisional. Penelitian ini merekomendasikan kajian lanjutan yang menyoroti ketahanan arsitektur tradisional terhadap perubahan iklim dan potensi integrasi teknologi modern dalam desain tanpa menghilangkan nilai-nilai budaya.

Kata kunci: Arsitektur tradisional Sasak,*Bale* Sade,Etnomatematika, Fungsi aljabar, Geometri

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

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INTRODUCTION

Mathematics is one of the branches of science that studies various concepts of numbers, shapes, and relationships between elements, has experienced significant development since ancient times (Siotto & Cignoni, 2024). At the beginning of its emergence, mathematics served as a tool to solve practical problems, such as time measurement, resource management, calculations in trade and various other problems in human needs. Over time, mathematical concepts are increasingly developing and expanding, not only in the scientific realm, but also in various dimensions of human life, including in various cultures and civilizations (Ruhiat et al., 2022). In everyday life, mathematics is often not seen explicitly, although it has actually been applied in various forms of cultural works, such as art, architecture, and handicrafts (Sohn et al., 2025). The application of mathematics in cultural contexts is at the core of ethnomathematics studies, which aim to identify and understand how people from different parts of the world apply mathematical concepts in their traditions and cultures.

Ethnomathematics plays an important role in bridging the relationship between culture and mathematics, because through this approach, we can understand the application of mathematical concepts in everyday life (Ramadhani et al., 2023). Ethnomathematics not only focuses on abstract mathematical theories, but also explores how mathematical practices develop in the context of local culture and traditions (Fitriyah & Syafi'i, 2022). One example of the application of ethnomathematics can be found in the design of the traditional *Bale* Sade house in Lombok. *Bale* Sade, which is the traditional house of the Sasak tribe, not only has aesthetic and functional values, but also contains mathematical principles contained in geometry and algebraic elements (Sahira et al., 2023). The structure of this building, consisting of symmetrical and proportional columns, roofs and walls, reflects the Lombok people's understanding of the concepts of balance and space that are in line with mathematical principles (Ramadhani & Abdullah, 2021). Therefore, the study of *Bale* Sade provides a deeper understanding of how mathematics is closely intertwined with local culture and community life.

The *Bale* Sade house design is an example of traditional architecture that incorporates geometric and algebraic principles to create a sturdy and functional residential space for the people of Lombok (Sahira et al., 2023). The structure of this house consists of essential elements, such as a strong roof, supporting walls, durable floors, and strategically placed posts, all of which are calculated using geometric principles to ensure stability and comfort (Sahira et al., 2023). In addition, the application of algebraic functions is used to obtain precise measurements and proportions, which not only enhance the aesthetic appeal but also strengthen the structural integrity of the building (Irawan et al., 2023). The use of materials such as wood and straw also supports the sustainability of the design and provides effective insulation, in line with environmentally friendly practices. Aside from the architecture of Lombok's traditional *Bale* Sade houses, *Bale* Sade houses also reflect local cultural values that fulfill practical needs (Labib, 2023). The combination of functionality and cultural values makes *Bale* Sade an outstanding example of traditional architecture.

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

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Based on the literature review, several previous studies were found that researched related to the bale sade traditional house by (Fauzi et al., 2020; Yazid & Mahmudah, 2020; Turmuzi et al., 2022; Fauzi et al., 2023; Irawan et al., 2023; Lalu & Nurmawanti, 2023; Musliana et al., 2024).Fauzi et al. (2020) explained that Sasak cultural products can be used as a source of learning mathematics, especially on elements of geometry which include rectangles, triangles, trapezoids, circles, rhombuses, kites, cones, cylinders, and pyramids. Learning resources derived from this Sasak culture if utilized properly will create meaningful mathematics learning for students. Yazid & Mahmudah, (2020) explained that a cultural approach in learning mathematics can be an effective strategy in instilling the character of love for mathematics. Ethnomathematics connects mathematical concepts with local wisdom, traditions, and daily practices of the community, thus making mathematics more contextual, meaningful, and interesting for students.

Turmuzi et al. (2022) explained that the mathematical concepts related to the ethnomathematics of local wisdom of Sasak culture consist of flat plane geometry, spatial geometry, geometry transformation concepts, measurement, volume of rotating objects, perimeter and area of flat plane shapes. Fauzi et al. (2023) mentioned that the motif (reragian) of the subahnale woven fabric is formed with a combination of geometric shapes, namely lines, triangles, rectangles and hexagons. These geometric shapes are arranged using mathematical models, namely translation, rotation and reflection.

Irawan et al. (2023) explained that the stages of needs analysis and ethnomathematics analysis. Needs analysis is related to student needs for mathematics learning media that is integrated with culture, mathematics and technology. Ethnomathematics analysis is generated from the shape of the community bale building, granaries, houses, dance arts, musical instruments and woven fabrics. There are many mathematical elements in the form of flat geometry and many philosophies contained in Sasak culture that must be preserved as part of strengthening the cultural character of Pancasila students. Lalu & Nurmawanti, (2023) mentioned in his research that there is a charge of geometry concepts in the form of flat geometry and geometry of space such as the concept of flat shapes of circles, squares, rectangles and triangles as well as the charge of space geomeri such as the space of cubes, beams, triangular pyramids, triangular prisms, cones and tubes. Musliana et al. (2024) explain that bale kambang, kolam (lake), *bale* pererenan, *bale* lodji, pura jagat nata, and pura kelepug. Various types of flat shapes are found in these structures, such as quadrilaterals, triangles and segments.

This research aims to explore and identify the application of algebra and geometry concepts in the traditional architectural design of Bale Sade, the traditional house of the Sasak people in Lombok. This research specifically aims to identify mathematical principles, especially algebra and geometry, which are reflected in the structural elements of the building such as the roof, poles, and walls. In addition, this research also aims to analyze the relationship between the architectural design of Bale Sade and mathematical concepts that are both functional and symbolic in the context of Sasak culture. Through the ethnomathematics approach, this research is expected to

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ISSN 2442-5419 (Online)

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reveal local cultural values represented through traditional building structures, as well as contribute to the development of ethnomathematics studies, especially in understanding the application of mathematical concepts in traditional architecture which has not been studied in depth.

RESEARCH METHODS

The approach used in this research is qualitative with a descriptive analysis method (Solikatun et al., 2021). A qualitative descriptive approach is an approach that tries to explain culture by making field observations based on facts. The data collection methods used are observation method, interview method and documentation (Rohimi, 2020). It is said to be descriptive because this research describes data based on objective facts according to the data found to explain concepts related to each other using words or sentences instead of using data or statistics. This research includes field research, which is a form of research conducted by researchers going directly in the field to get valid information about the Lombok Traditional *Bale* Sade as the cultural identity of the Sasak people of Lombok. The place of this research is in Rembitan Village, Pujut District, Central Lombok. The methods and analysis used are as in Figure 1.

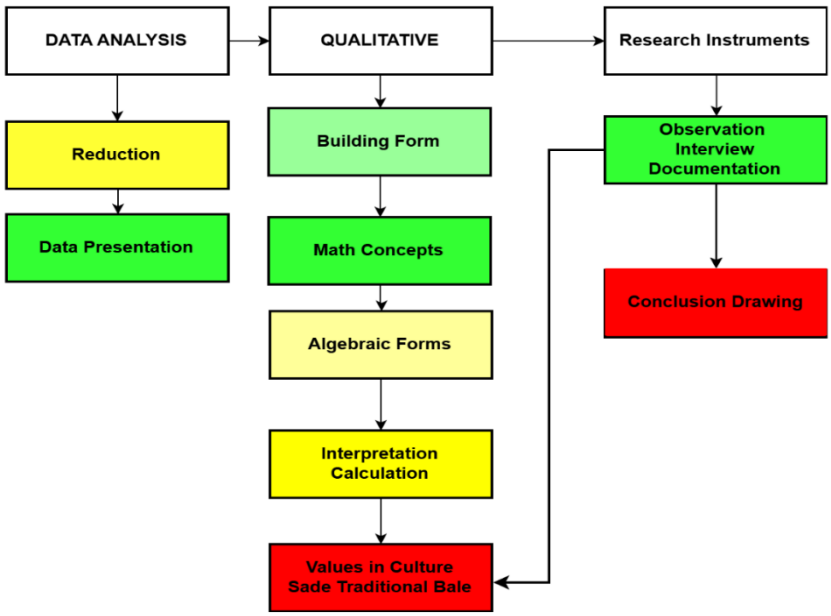

Figure 1. Components of data analysis (Miles and Hubberman)

Figure 1 explains data analysis using the Miles & Huberman approach which consists of 4 types of activities in data analysis, namely data collection, data reduction, data display, and conclusions (Azwar et al., 2024; Fadli, 2021). (1) Data collection, Researchers conducted a literature study first to study traditional Lombok *Bale* Sade, by looking at various previous studies and then verifying and analyzing at this stage, data were collected from various relevant sources, such as direct observation of the *Bale* Sade structure, interviews with several resource persons, TA (Traditional Leaders), and PW (Tour

ISSN 2089-8703 (Print)
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Guides) in Rembitan Village, Pujut District as well as literature studies related to traditional Lombok architecture and ethnomathematics studies.

The data collected includes geometric aspects of the building such as symmetry, proportion, and balance, as well as the use of algebraic principles in the calculation of building materials and dimensions; (2) Data reduction, the researcher conducts data reduction by selecting and sorting from all the data that has been taken from observations in the village of Rembitan, interviews with several resource persons, TA (Traditional Leaders), and PW (Tour Guides) related to information on the traditional *Bale* Sade and directly related to the application of mathematical concepts, such as calculating the dimensions of poles, roofs, and building materials, will be selected for further analysis. Data reduction also involves grouping data based on categories, such as geometry, algebra, and local wisdom in Sade bale design; (3) Display data (data presentation), after all data is obtained and reduced, researchers can visualize information in the form of tables, diagrams, or images that illustrate the relationship between geometric elements in the design of the house and the application of algebra in the calculation of building structures. Data display also includes narratives that describe how mathematical concepts are practically applied in the design of these traditional houses; (4) Conclusions are drawn from the results of the discussion of Lombok Traditional *Bale* Sade which have been described in the results and discussion.

RESULTS AND DISCUSSION

Bale Sade is a traditional house of the Sasak people that is structurally and functionally closely related to their social and cultural values. *Bale* Sade not only functions as a living space, but also as a symbol of the life of the Sasak people who are oriented towards harmony between humans, nature and God. As for the architecture, bale sade consists of several elements, such as supporting poles, a pyramid-shaped roof, and walls made of woven bamboo. As shown in Figure 2.

Figure 2. Sade traditional house

Based on Figure 2, it shows the appearance and shape of the traditional sade data house in the Sasak community, the indigenous tribe that inhabits the island of Lombok, West Nusa Tenggara. This house is part of a cultural heritage that reflects the local wisdom and traditions of the Sasak people in building their homes.

History and Social Context of *Bale* Sade

Based on the opinion of traditional leaders, *Bale* Sade is one of the typical traditional architectures of the Sasak people who still maintain the traditional traditional building forms left by the ancestors. Sade village is taken from an ancient Sanskrit name meaning medicine. This hamlet has existed since about 1,100 years ago, consisting of 150 houses inhabited by 150 families with a total population of 700 people and has been inhabited by 15 generations. Sade Village has five main traditional

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

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buildings, namely Beruga Sekenam, a place used as a place of deliberation in solving a problem, circumcision events and wedding events. Then there is Beruga Sekebat which is used for akikah activities. There are also jajar halls, kodong halls and farmer's halls, as well as barns that have a distinctive shape. A typical Sasak house has two rooms, namely the front room for parents and children, and the back room for the kitchen and the girl's bed. In addition, there is a low terrace that has three stairs. The low terrace of the house means that guests should bow down. While the meaning of three steps is to remember the Almighty God, remember the mother and father. As in Figure 3.

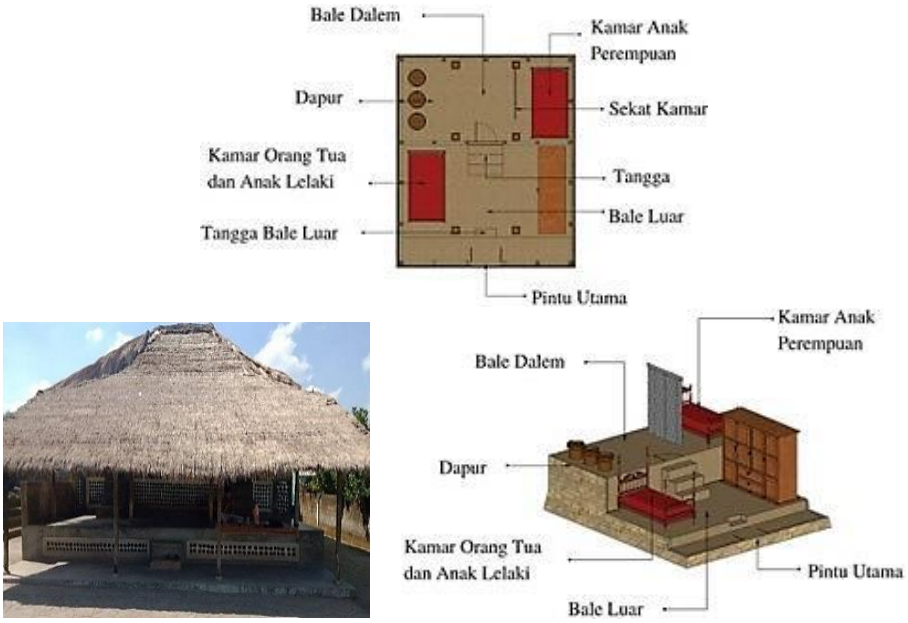

Figure 3. *Bale* sade and bale sade floor plan

Figure 3 illustrates the plan and structure of *Bale* Sade, which consists of Bale Dalem, girls' rooms, parents' and boys' rooms, the kitchen, *Bale* Luar, and the main door. *Bale* Dalem acts as the core space for family activities, including the sleeping quarters and private areas. The girls' rooms are placed separately to maintain privacy and adhere to traditional values regarding restrictions on interaction between family members of different genders. Rooms for parents and sons reflect the separation of space based on gender and age within the family. The placement of the kitchen inside the house shows the traditional concept where cooking is an integral part of daily life. The *Bale* Luar serves as a terrace or semi-open space that is generally used to receive guests or relax. The main door, which is usually designed low, symbolizes respect for guests.

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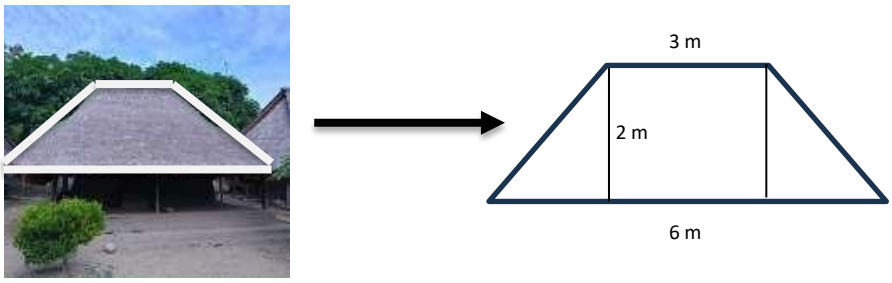

Figure 4. Depicting the roof of the front side of *Bale* Sade

Struktur dan Bentuk Geomertris pada Bale Sade

Based on Figure 4 from a geometry point of view, the ethnomathematical element is found on the front roof of the *Bale* Sade structure. This component serves to protect the top of the building and has the geometric shape of an isosceles trapezoid. An isosceles trapezoid is characterized by two sides that have the same length, which are the sides that form right angles. In the formula L = 1/2 (a + b) × t, each symbol has a meaning, namely (L) Area of the trapezoid (the result of the calculation of the building area in square meters), (a) Length of the upper side of the trapezoid (in meters), (b) Length of the lower side of the trapezoid (in meters), (t) Height of the trapezoid (perpendicular distance between the upper and lower sides), (m) Meter, the unit of length used in the calculation. The formula for calculating the area of a trapezoid is expressed as follows:

$$L = \frac{1}{2}(a+b) \times t$$

$$L = \frac{1}{2}(3m + 6m) \times 2m$$

$$= \frac{3m + 6m}{2} \times 2m$$

$$L = 9m$$

Based on the trapezoidal formula on the roof of the Sade traditional *bale* house, there is an area of 9m. According to the cultural philosophy of the Sasak indigenous people, the number 9 has a philosophical meaning that is closely related to balance, spirituality and the cycle of life. This number is often seen as a symbol of perfection and harmony between the physical and spiritual worlds, which represents the journey of human life from birth to return to origin. In addition, the number 9 also reflects the social system of the Sasak people who prioritize mutual cooperation and describes the stages of human life from childhood to achieving wisdom.

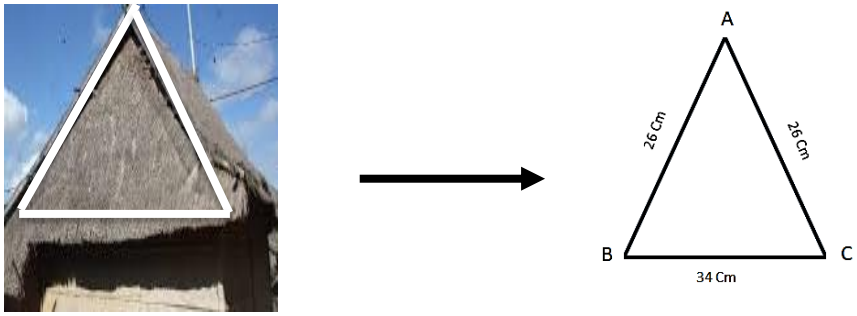

Figure 5. Depicting the side roof of *Bale* Sade

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

DOI: https://doi.org/10.24127/ajpm.v14i3.12845

Based on Figure 5 from a geometry point of view, the ethnomathematics element is found on the side roof of the *Bale* Sade structure. This component functions as a protector of the top of the building and has the geometric shape of an isosceles triangle. isosceles triangles are characterized by two sides that have the same length, namely the sides that form right angles. In the formula K = AB + BC + CA, each symbol has a meaning, namely (K) The perimeter of the triangle (the result of the sum of all sides of the triangle in cm), (AB) The length of the first side of the triangle, (BC) The length of the second side of the triangle, (CA) The length of the third side of the triangle, (cm) Centimeter, the unit of length used in the calculation. The formula for calculating the perimeter of this triangle is expressed as follows:

$$K = AB + BC + CA$$
$$= 26cm + 34cm + 26cm$$
$$K = 86cm$$

Based on the triangular formula on the side roof of the Sade traditional bale house, there is a circumference of 86cm. According to the Sasak cultural philosophy, the number 86 obtained from the perimeter of the side roof of the Sasak traditional *bale* can be interpreted as a symbol of balance and harmony in life. the perimeter of the side roof which amounts to 86 cm can also be interpreted as a representation of the balance between the three main elements, namely the foundation of life (humans and society), protection (nature), and spirituality (relationship with God). The triangular roof itself symbolizes stability and resilience, reflecting the philosophy of the Sasak people in facing the changing times without abandoning their local wisdom.

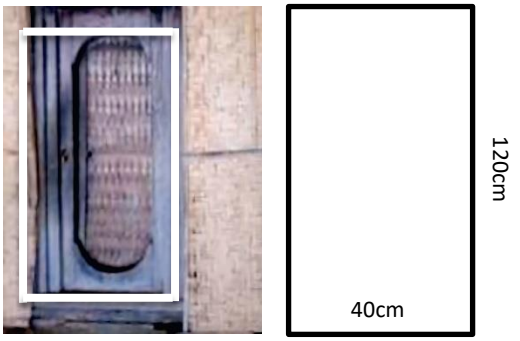

Figure 6. Sade *Bale* door

Based on Figure 6 from a geometry point of view, the ethnomathematical element is found in the door of the *Bale* Sade structure. This component functions as a small-sized entrance and exit that reflects cultural values that respect guests and hosts and has a rectangular geometric shape. Rectangles are characterized by two sides that have the same length and the same width. In the formula L = P × l and K = 2 × (P + l), each symbol has a meaning, namely (L) Rectangle area, (P) Rectangle length, (l) Rectangle width, cm² = Square centimeter, (K) Rectangle perimeter. The formula for calculating the Area and perimeter of this rectangle is expressed as follows:

$$L = P \times l$$
$$= 120cm \times 40cm$$
$$L = 4.800cm$$
$$K = 2 \times (P + l)$$
$$= 2 \times (120cm + 40cm)$$
$$= 2 \times 160cm$$
$$K = 320cm$$

Based on these results, it can be seen that the roof of the Sade house in the front view has a trapezoidal shape formed from a roof structure that rises high in the center and slopes down on both sides (Hao et al., 2024). This design serves to provide maximum protection against weather conditions,

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

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such as heavy rain and scorching heat, but also represents the philosophy of life of the Sasak people. The tapered top symbolizes the vertical relationship between humans and the Creator, while the flared bottom reflects the horizontal relationship between individuals in the community as well as interaction with the surrounding environment. On the other hand, the roof of the Sade house is triangular in shape, reflecting the principles of balance and harmony in life. Practically speaking, the steep slope of the triangular roof makes it easier for rainwater to flow quickly to avoid puddles and leaks. The use of reeds as roofing material provides traditional aesthetic value and functions adaptively to the local climate, where the reeds need to be replaced every six to seven years to maintain the effectiveness of protection against extreme weather. based on the research of Nezhad et al., (2023)that the rectangular shape and made of wood and bamboo also have a deep philosophy. The door is not only the main access for residents of the house, but also reflects the social values of the Sasak people, such as mutual respect. The low design of the door requires everyone who enters to bow as a sign of respect to the homeowner and appreciation of local cultural values. But it also illustrates the cultural values and local wisdom that are passed down from generation to generation in the life of the Sasak people.

Application of Algebraic Function Concept in *Bale* Sade Architecture

The concept of algebraic functions plays a significant role in the traditional architecture of *Bale* Sade, especially in the planning stage, structural calculations and optimization of space use. *Bale* Sade architecture contains mathematical elements that not only beautify the design but also improve the functionality of the building. One example of a traditional house that has a distinctive structure is *Bale* Sade, a traditional house of the Sasak tribe of Lombok, which is designed by considering environmental aspects, social needs, and space efficiency. It can be seen in Figure 7.

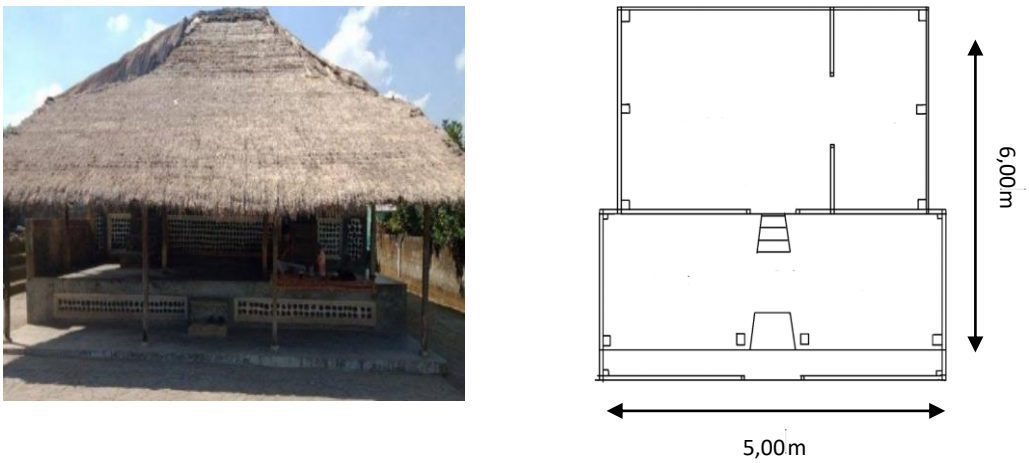

Figure 7. *Bale* sade and bale sade floor plan

Figure 7 shows the building plan of *Bale* Sade, showing the main spaces of *Bale* Dalem and *Bale* Luah with their distinctive divisions, where *Bale* Dalem serves as a sacred place for traditional ceremonies and religious

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

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activities, while *Bale* Luah is used for receiving guests and social activities. The structure shows two main sections connected by a staircase, reflecting the relationship between the lower and upper floors. Each space has a specific function that supports the daily activities of the occupants. In the design of buildings such as Bale Sade, the concept of algebraic functions is used to determine the area and volume of space, building proportions, load distribution, and ventilation efficiency. Through this mathematical approach, the structure of the house can be built optimally so that it remains sturdy, comfortable, and adaptable to the surrounding environment. In the formulas L = P × L, Ltotal = 2 × L, V = P × l × t, and Vtotal = 2 × V, each symbol has a meaning, namely: (L) Rectangular area, (P) Building length, (L) Building width, (m^2) Square meters. (Ltotal) The total area of the two parts of the building being calculated, (L) The area of one part, which is 30 m^2. (V) Volume of space, (P) Length of building, (l) Width of building, (t) Height of building, (m^3) Cubic meters. The formulas for calculating the Area and Volume of this space are expressed as follows:

Calculating the area of the space:

$$L = P \times L = 6 \times 5 = 30m^2$$

Total Area

$$L_{total} = 2 \times L = 2 \times 30 = 60m^2$$

Calculating the Volume of Space

$$V = p \times l \times t = 6 \times 5 \times 2 = 60\ m^3$$

Total Volume

$$V_{total} = 2 \times V = 2 \times 60 = 120\ m^3$$

Based on the above results, *Bale* Sade is a traditional house of the Sasak tribe in Lombok which has a simple but functional structure. The plan shows a rectangular-shaped building with a distinctive division of space, including the main room, central area, and connecting stairs (Saptaningtyas et al., 2023). In traditional architecture such as Bale Sade, the concept of algebraic functions is applied in various aspects, from the calculation of space area and volume, building proportion, load distribution, to ventilation optimization. In the calculation of space area and volume, the floor area of this building is 30 m^2, while the space volume reaches 60 m^3, ensuring efficient use of space as well as structural balance. In addition, the proportion of height to length or width of the building has a ratio of 1:3, which maintains the aesthetic balance and stability of the building. Structurally, this house is divided into two main parts, namely Bale Dalem as a private space used for family needs, and Bale Luah which functions as a semi-public space for social activities and interaction with the community. This division of space reflects the concept of privacy and openness in the life of the Sasak people.based on research by Saputra et al. (2024) explained that, the use of natural materials such as wood, bamboo, palm fiber, and clay shows the principle of sustainability and harmony with nature. The roof of the house made of thatch plays a role in keeping the room cool, while the floor made from a mixture of clay and buffalo dung is believed to have a natural antiseptic function that strengthens the structure of the house.

Each element in the architecture of *Bale* Sade has a symbolic meaning related to the philosophy of life of the Sasak people. The connecting staircase between *Bale* Luah and *Bale* Dalem symbolizes the journey of human life from social space to a more sacred space (Shammari et al., 2024). In addition, the roof shape that tapers

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

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upwards represents the relationship between humans and God, while reflecting the principles of simplicity and firmness in living life. The layout of the house is also organized based on local beliefs and environmental conditions, in accordance with the concept of energy balance in the cosmology of the Sasak people. *Bale* Sade architecture not only functions as a place to live, but also as a manifestation of cultural values and traditions passed down from generation to generation (Mustafa & Ali, 2024).

CONCLUSIONS AND SUGGESTIONS

This study aims to examine the application of geometry concepts and algebraic functions in the traditional architecture of Bale Sade as a representation of ethnomathematics in the culture of the Sasak people. The results show that Bale Sade contains various geometric shapes, such as isosceles trapezoids on the front roof, isosceles triangles on the sides of the roof, and rectangles on the door. These shapes not only function structurally, but also contain symbolic meanings that reflect the values of Sasak life, such as balance, spirituality, and respect for others. In addition, the application of the concept of algebraic functions is implicitly seen in the calculation of area, perimeter and volume of the room, which reflects a mathematical approach in planning buildings that are efficient and adaptive to the environment. These findings show that Sasak traditional architecture has integrated cultural values and mathematical principles harmoniously, so it has the potential to be used as a contextual learning resource in learning mathematics in elementary schools. Based on these findings, it is recommended that further research develop ethnomathematics-based learning media or teaching modules by lifting Bale Sade architecture as a local context. In addition, it is necessary to conduct similar studies on other traditional buildings in various regions to expand the scope of Indonesian ethnomathematics.

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