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EXPLORATION OF GEOMETRIC CONCEPTS IN THE MINANGKABAU PENCAK SILAT: AN ETHNOMATHEMATICS STUDY

EKSPLORASI KONSEP GEOMETRI DALAM PENCAK SILAT MINANGKABAU: STUDI ETNOMATEMATIKA

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Abstract

Pencak Silat, as part of the Minangkabau cultural heritage passed down through generations, represents a unique intersection between cultural practices and mathematical concepts, making it a valuable subject for ethnomathematics research. While numerous studies have explored ethnomathematics in various cultural contexts, the relationship between Minangkabau Pencak Silat and mathematics education remains underexplored. This study seeks to address this gap by examining the mathematical concepts embedded in the movements of Minangkabau Pencak Silat. Using a descriptive qualitative approach, data were collected through participant observation, in-depth interviews, and documentation involving Minangkabau martial artists from different silek academy, one cultural leader, and three silek observers. The study examines a range of movements-such as step patterns, stances, strikes, kicks, elbows, and defensive techniques-analyzing them to reveal mathematical principles such as angles, parallel lines, intersecting lines, and overlapping lines. Specifically, the study identifies the eight directions of movement and four basic step patterns-straight, zigzag, triangular, and square-as well as the geometric structures found in other silat techniques. The findings indicate that Minangkabau Pencak Silat can be used as a contextual learning tool for teaching geometry, offering culturally relevant and practical examples for students. This research contributes to a broader understanding of how cultural practices can enhance learning and serves as a reference for educators seeking to integrate local cultural elements into mathematics teaching.

Keywords: ethnomathematics, Minangkabau pencak silat, geometric concepts, cultural mathematics education.

Abstrak

Pencak Silat, bagian dari warisan budaya Minangkabau yang diwariskan secara turun-temurun, menggabungkan praktik budaya dan konsep matematika, menjadikannya subjek menarik dalam studi etnomatematika. Meskipun telah banyak kajian etnomatematika, penelitian tentang Pencak Silat Minangkabau dan potensinya dalam pembelajaran matematika masih sangat terbatas. Penelitian ini bertujuan untuk mengisi kesenjangan tersebut dengan mengeksplorasi konsep-konsep matematika yang ada dalam gerakan Pencak Silat Minangkabau. Menggunakan pendekatan kualitatif deskriptif, data dikumpulkan melalui observasi partisipatif, wawancara mendalam, dan dokumentasi yang melibatkan pesilat Minangkabau dari berbagai perguruan, satu

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tokoh adat, dan tiga pemerhati silek. Penelitian ini mencakup gerakan langkah, posisi kuda-kuda, pukulan, tendangan, sikutan, dan sikap bertahan, yang dianalisis untuk mengungkap prinsip-prinsip matematika seperti sudut, garis sejajar, garis berpotongan, dan garis berimpit. Penelitian juga mengidentifikasi delapan arah gerakan dan empat pola langkah dasar-lurus, zigzag, segitiga, dan persegi-serta struktur geometris dalam gerakan silat lainnya. Hasil penelitian menunjukkan bahwa Pencak Silat Minangkabau dapat menjadi alat pembelajaran kontekstual yang efektif untuk mengajarkan geometri, memberikan contoh yang relevan secara budaya kepada siswa. Penelitian ini memperluas pemahaman tentang bagaimana praktik budaya dapat mendukung pembelajaran dan menawarkan panduan bagi pendidik untuk mengintegrasikan elemen budaya lokal dalam pengajaran matematika.

Kata kunci: *etnomatematika, pencak silat Minangkabau, konsep geometri, pendidikan matematika berbasis budaya*.

INTRODUCTION

Ethnomathematics, as explained by William Barton in Nilah Karnilah (2013), is a field of study that examines how a group of people within a specific culture understand, express, and utilize mathematical concepts and practices, which researchers recognize as part of mathematics. According to Barton (2015), ethnomathematics explores how particular cultural groups perceive, express, and apply mathematical concepts that often differ from the formal concepts taught in schools. In this context, local culture can serve as a rich source for more contextual and relevant mathematics learning for students (Abdullah et al., 2015). One emerging approach is the use of ethnomathematics as an innovative teaching method in mathematics education, where local culture is integrated into the learning process to make it more contextual and relatable to students' daily lives (Wahyuni et al., 2013). However, this field still requires further implementation in the educational context in Indonesia.

Ethnomathematics research has been conducted in various cultural areas, such as architecture, weaving, agriculture, kinship relations, ornaments, and religious practices, which often reflect natural patterns or abstract systems. For example, Fitriza (2018) explored geometric transformations in the ornaments of the *Rumah Gadang*. Kiram (2020) examined ethnomathematics in *Silungkang songket* weaving, associating it with the congruence of geometric shapes. Meanwhile, Utami et al. (2020) studied ethnomathematical concepts found in Borobudur Temple, integrating religious, moral, cultural, and mathematical values. In agriculture, Ikrimah (2017) described how ethnomathematics can be applied to determine the number of rice seedlings and the ratio of water and liquid fertilizer required for spraying rice crops.

The classical view of mathematics, as D’Ambrosio (1990a, 1990b) argues that the widespread failure in mathematics is a social issue, driven by the filtering mechanisms of mathematics education, which operate through the cultural nature of the subject-what he terms the "social terrorism" of mathematics. In the context of ethnomathematics, such as Minangkabau Pencak Silat, this concept highlights the importance of integrating cultural practices into mathematics education. By doing so, abstract mathematical concepts like angles and symmetry can be taught through culturally relevant

examples, reducing exclusion and marginalization in traditional math education, and making learning more accessible and engaging for students. This approach aligns with D'Ambrosio's vision of creating a more inclusive, culturally responsive form of mathematics education.

Despite numerous studies highlighting the relationship between mathematics and culture, there is still a lack of research exploring the application of ethnomathematics in martial arts, particularly Pencak Silat. This indicates a gap in the ethnomathematics literature that has yet to explore the use of martial arts as a context for learning geometry. This research aims to fill that gap by exploring the movements in Minangkabau Pencak Silat and how these movements can be related to geometric concepts. Pencak Silat is a traditional Indonesian martial art that has developed since the kingdom era in the Nusantara region, particularly in Minangkabau, West Sumatra. Minangkabau *Silat (Silek*) has been passed down from generation to generation and serves as a means of self-defense, entertainment, and a tool for conveying moral messages through the traditional drama, *Randai*. Additionally, *Silek* plays an important role in protecting the *nagari* (village) from external threats.

Pencak Silat is not only valued as a martial art but also as a comprehensive educational medium. Learning Pencak Silat hones both physical and mental skills while also connecting practitioners to their daily lives and surrounding environment. This study examines the movements in Minangkabau Pencak Silat, which include footwork patterns, stances, attacks, and defensive postures, all of which contain mathematical concepts such as angles, parallel lines, intersecting lines, and other geometric patterns. This analysis is part of an ethnomathematics approach, aiming to connect culture with mathematics education. This approach allows mathematical concepts embedded in cultural practices to be introduced to students through a context that is culturally familiar and meaningful to them.

According to Mulyana (2013), one of the aspects of Pencak Silat that is particularly interesting to study through ethnomathematics is the footwork or step patterns. Footwork in Pencak Silat refers to changes in foot position made during attacks or defenses, always accompanied by body posture and hand movements. The directions of these steps can be analyzed mathematically through geometric concepts such as straight lines, perpendicular lines, and diagonal lines. The combination of these movements creates specific step patterns, such as straight steps, zigzag, triangular, horseshoe (*ladam*), and S-shaped steps (Kriswanto, 2015). Previous studies have explored step patterns in the context of ethnomathematics, such as the research by Wicaksono et al. (2020), which examined the step patterns of Pencak Silat in the Riau Islands, and the study by Sandhi et al. (2018), which analyzed the step patterns in the *Jejer Jaran Dawuk* dance in Banyuwangi.

The stance (*kuda-kuda*) in Minangkabau Pencak Silat involves the balanced distribution of body weight between both feet, demonstrating fundamental concepts of balance and stability in physics and

mathematics. According to Suparman (2016), a stable stance creates torque that contributes to the fighter's balance, and the angles formed by the legs in the stance can be analyzed using the principles of triangle geometry. Another study by Santoso (2015) revealed that the angles formed in both front and side stances reflect mathematical concepts. These movements create simple geometric structures relevant to concepts taught in high school geometry, such as parallel lines and intersections. Therefore, the mathematical analysis of these stances offers opportunities to use martial arts movements as a contextual tool for teaching geometry.

Additionally, offensive moves in Pencak Silat, such as punches, kicks, and elbow strikes, also contain identifiable mathematical elements. Agustini (2019) explains that in traditional martial arts, punches often involve a right angle between the arm and the body, where torque and momentum play crucial roles in the power of the strike. This angle can be further analyzed to help students understand the application of angles in real-life scenarios.

Similarly, defensive postures such as evasions and blocks in Minangkabau Pencak Silat reflect angular movement in space. According to research by Kristanto (2017), defensive movements in martial arts create patterns of rotation and angular shifts aimed at avoiding attacks. These patterns can also be analyzed using geometric concepts. Defensive stances in Pencak Silat teach students how angles are used to change the direction of movement and minimize the risk of being hit by an opponent’s attack.

Based on this background, this study aims to identify and thoroughly examine the geometric concepts embedded in the movements of Minangkabau Pencak Silat and explore how these concepts can be utilized as contextual and relevant teaching tools in geometry education. This research also seeks to address the gap in ethnomathematics literature, which has not extensively explored martial arts as a source for mathematical study. In line with the research by Abdullah et al. (2015), which emphasizes that integrating culture into mathematics education can strengthen students' understanding of mathematical concepts, this study suggests that Minangkabau Pencak Silat can serve as a culturally relevant teaching tool. By using examples from local culture, students can learn mathematics through more practical and meaningful experiences. This approach is expected to bridge the gap between local culture and formal education, as discussed by Barton (2015), where ethnomathematics serves as a bridge between two worlds, enabling students to gain a deeper understanding of their lessons. Thus, this study offers an innovative approach to teaching mathematics by using local cultural contexts as instructional aids.

RESEARCH METHODOLOGY

This study aims to uncover the mathematical concepts embedded in the movements of Minangkabau Pencak Silat through an ethnomathematics approach. This section outlines the research type, research subjects, research procedures, instruments, data collection techniques, and data analysis techniques used in this study.

Research Type

This study employs a descriptive qualitative approach to explore and identify the mathematical concepts embedded in the movements of Minangkabau Pencak Silat. The research focus extends beyond footwork patterns, covering various other elements in Pencak Silat, such as stances, punches, kicks, elbow strikes, and defensive styles. A qualitative approach is chosen because this research seeks to uncover the cultural meanings, and mathematical concepts present in the movements of Minangkabau Pencak Silat through direct observation and in-depth interviews.

Qualitative research allows for an in-depth exploration of cultural phenomena and the interpretation of meanings from participants' perspectives, which aligns with Creswell's (2018) findings that this approach is suitable for studies aimed at understanding social and cultural phenomena within a broader context. A descriptive approach is used to provide a detailed depiction of Pencak Silat movements, and the mathematical concepts embedded in each movement. This approach also enables the researcher to interpret observed phenomena from the participants' perspectives (including silat practitioners, cultural figures, and *Silek* enthusiasts). This aligns with Bogdan & Biklen's (2007) assertion that a descriptive approach in qualitative research offers a richer and more contextual understanding of the research subject.

Time and Location of Research

This research was conducted from June 13, 2020, to July 21, 2020. Fieldwork took place in two locations: Nagari Halaban, Lareh Sago Halaban District, Lima Puluh Kota Regency, and Payakumbuh City, West Sumatra. These locations were selected due to the presence of active silat schools that continue to teach and preserve traditional Minangkabau Pencak Silat. This allowed the researcher to observe authentic Silek practices in an environment conducive to the preservation of local cultural heritage.

Research Subjects

The subjects of this research involve several groups who are considered to have a deep understanding of Minangkabau Pencak Silat, including:

1. **Four Minangkabau Pencak Silat practitioners** from four different schools: Sikoka Harimau Damam (Halaban), Silaturrahmi (Halaban), Kuciang Bapaluak (Aia Baba-Halaban), and Minsai Al-Fitrah (Koto

Nan Ampek – Payakumbuh). These practitioners were selected based on their expertise and practice of Minangkabau Pencak Silat for over 10 years.

2. **One cultural figure**, the *wali nagari* of Halaban, chosen as a representative of local cultural and traditional knowledge closely linked to Pencak Silat.
3. **Three Silek enthusiasts**, who regularly observe and study Pencak Silat movements across various *nagari*, were also included in the research to provide a broader perspective.

The selection of subjects was carried out using purposive sampling, where participants were chosen based on their knowledge and involvement in Minangkabau Pencak Silat, aligning with the needs of this study.

Data Collection Procedure

This research was conducted through several stages as follows:

1. **Preparation Stage**: In this stage, the researcher prepared the necessary instruments for observation and interviews, including interview guides, field notes, and documentation tools (camera and voice recorder). As Creswell (2018) states, preparing instruments such as interview guides and field notes is a crucial component in qualitative data collection, ensuring that relevant and valid data can be gathered.
2. **Participant Observation**: The researcher directly participated in Pencak Silat training sessions at different schools to observe the movement patterns performed by the practitioners. Each observation session lasted 2-3 hours and was conducted six times during the research period. The observations focused on footwork, including step patterns and formations, stances, basic movements, and movements during sparring. According to Spradley (1980), participant observation allows researchers to deeply understand the cultural meanings being observed through direct involvement, resulting in richer and more in-depth data.
3. **In-Depth Interviews**: Semi-structured interviews were conducted, with each session lasting approximately 60-90 minutes per subject. The interviews aimed to uncover the meaning behind each Pencak Silat movement as well as the cultural concepts associated with these movements. Interview questions included the philosophy of the movements, the cultural values embodied, and the relevance of the movements to geometric principles. As noted by Kvale (1996), semi-structured interviews are an effective tool for extracting in-depth and flexible information from participants, as they allow for variation in responses and further exploration based on participant answers.
4. **Documentation**: During the observation, the researcher documented the Minangkabau Pencak Silat movements performed by the practitioners through photos and videos. The purpose of this

documentation was to visually record each movement pattern for further, in-depth analysis. Yin (2003) suggests that visual documentation, such as photos and videos, is vital in qualitative research, as it can strengthen data analysis and validate findings based on concrete evidence.

Instrument and Data Collection Techniques

The instruments used in this research include:

1. **Semi-Structured Interview Guide**: This instrument was used to guide in-depth interviews with the subjects, focusing on the philosophical, cultural, and mathematical aspects related to Pencak Silat.
2. **Observation Notes**: The researcher recorded each observed movement, including footwork patterns, direction of movement, formations, stances, attacks, and defenses. These notes were supplemented with initial interpretations of potential mathematical concepts embedded in the movements.
3. **Camera and Recording Device**: A camera was used to capture photos and videos of Minangkabau Pencak Silat movements, while a voice recorder was used to record the interviews with research subjects.

Data Analysis Techniques

This research utilized the interactive model data analysis from Miles and Huberman (1994), which was refined by Basrowi (2008), involving three main stages:

1. **Data Reduction**: The data collected from observations, interviews, and documentation were simplified and focused on the main themes related to footwork, stances, punches, kicks, elbow strikes, and defenses, as well as the identified mathematical concepts. Irrelevant data were filtered out, ensuring that only information directly related to the study was analyzed further.
2. **Data Display**: The reduced data were presented in the form of descriptive narratives and geometric visualizations. Diagrams and illustrations were used to clarify the patterns and mathematical principles within each movement.
3. **Conclusion Drawing and Verification**: The researcher drew preliminary conclusions based on the presented data and then verified these conclusions through discussions with the research subjects to ensure the accuracy of interpretations. The final results are expected to describe the mathematical concepts embedded in Minangkabau Pencak Silat footwork and their relevance in mathematics education.

RESEARCH RESULT AND DISCUSSION

Footwork Movements in Minangkabau Pencak Silat

In Minangkabau Pencak Silat, the footwork patterns cover various directions and forms that can be analyzed through geometric concepts. The footwork in *Silek*, or Minangkabau Pencak Silat, serves as a fundamental technique used to change the position of the fighter during both attacks and defenses. Based on the direction of movement, the footwork is divided into eight directions known as *lapan panjuru mato angin* (eight points of the compass), which consist of:

1. Step forward.
2. Step diagonally forward to the right.
3. Step to the right.
4. Step diagonally backward to the right.
5. Step backward.
6. Step diagonally backward to the left.
7. Step to the left.
8. Step diagonally forward to the left.

As shown in Figure 1, the directional footwork in Silek divides a circle into eight equal parts, as depicted in Figure 2. Based on the sexagesimal system or base-60 system, the total angle of one complete circle is 360 degrees (60 x 6) (Fathani, 2009). Therefore, the angle formed by each direction in Minangkabau Pencak Silat footwork is 45° (360° divided by 8). Each step forms a regular pattern and can be analyzed using basic geometric concepts.

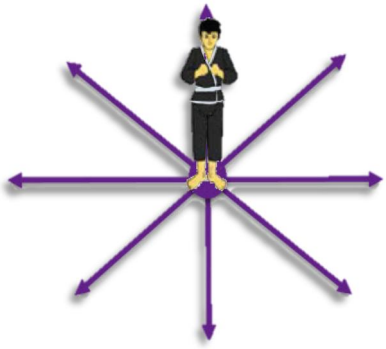

Figure 1. Directional Steps in Minangkabau Silek

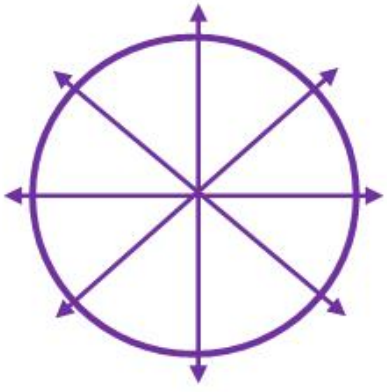

Figure 2. Ethnomathematics in the Directional Steps of Minangkabau Silek

In the context of Minangkabau Pencak Silat, the footwork patterns involve circular movements directed towards the eight points of the compass, forming a geometric circle with clearly divided angles. This is similar to the findings of Siregar et al. (2017) in their ethnomathematics study on traditional dance, which also divides movement space into several symmetrical sections. This research identifies that such patterns can be used to teach the concepts of angles and symmetry in geometry.

These footwork movements can be performed in three main positions: straight, perpendicular, and diagonal. When these footwork movements are combined with other movements, more complex step patterns emerge. According to *The International Competition Regulation* (Nugroho, 2005), there are six footwork patterns: (1) straight pattern; (2) zig-zag pattern; (3) horseshoe pattern; (4) triangle pattern; (5) square pattern, and (6) "S" shaped pattern. However, in Minangkabau *Silek*, there are at least four commonly used patterns:

1. **Pola langkah luruih** (straight pattern)
2. **Pola langkah patah siku** (zig-zag pattern)
3. **Pola langkah tupang tigo suduik** (triangle pattern)
4. **Pola langkah tupang ampek suduik** (square pattern)

These step patterns, frequently utilized in *Silek Minangkabau*, can be analyzed geometrically and provide a foundation for understanding how mathematical concepts are embedded in cultural practices.

a. *Pola Langkah Luruih* (Straight Pattern)

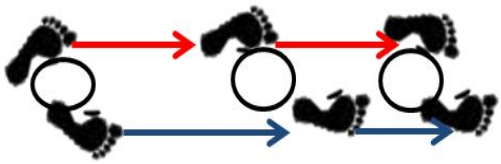

Figure 3. *Luruih*/Straight Step Pattern

Figure 4. Ethnomathematics Findings in the Luruih/Straight Step Pattern

Two perpendicular lines will intersect at one point, forming a 90° angle. Based on Agus Solokin's (2017) analysis of Euclid's concept of parallelism, it is stated that if two lines are perpendicular to the same line, then those two lines are parallel to each other. Parallel lines can also be understood as two lines that, when extended, will never intersect or meet at a common point.

In the *pola langkah luruih* (straight pattern), when the silat practitioner stands upright, they initiate the step by moving their feet so that they angle diagonally toward the front left and right, with the right foot slightly ahead of the left. In this position, if a straight line is drawn from the practitioner's heels, it will form two perpendicular lines that intersect, as the feet angled in opposite directions create a 90° or perpendicular angle (a).

Next, the practitioner lifts the right foot forward to step, followed by the left foot. When both feet are facing forward, if lines representing the movement of the feet are drawn, they will appear as two parallel lines (b).

The straight step is a basic movement where the practitioner steps forward or backward in a straight line. This movement illustrates two parallel lines between the feet, reflecting the principle of parallel lines in geometry. Wicaksono et al. (2020) found that the straight step in martial arts creates a fundamental geometric pattern, where both feet move in the same direction and will never intersect, even if extended. Additionally, this straight step creates a line that symmetrically divides the space, as described by Agustini (2019) in her analysis of linear movements in traditional martial arts.

b. *Pola Langkah Patah Siku* (Zigzag Pattern)

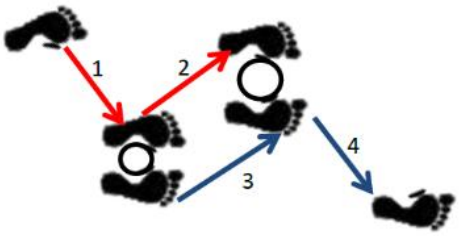

Figure 5. Zig-Zag/*Patah Siku* Step Pattern

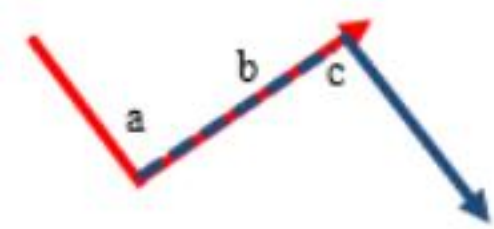

Figure 6. Ethnomathematics Findings in the Zig-Zag/*Patah Siku* Step Pattern

In the *pola langkah patah siku* or zig-zag pattern, the initial position of the *pandeka* (silat practitioner) is to form a front stance diagonally toward the front right. The next step involves closing the movement by lifting the left foot forward until the heels meet. Then, the practitioner steps the left foot forward again to form a diagonal front-left stance. If a line is drawn to represent the movement of the left foot, it will form a 90° angle.

According to Sari (2022) and Agustini (2019), an angle is formed by two rays that share a common endpoint, which is called the vertex. The angle formed by the foot movement in the *pola langkah patah siku* is a right angle, measuring 90° (a).

To step forward, the practitioner then steps the right foot until both heels are aligned. When the right foot moves, if a line is drawn to depict the movement, it will overlap with the line representing the previous left foot movement. Thus, the two lines appear as though they are merged into one (b). Two lines are said to overlap if they lie on top of one another and are in the same direction, making them appear as a single line (Yolanda & Refnywidialistuti, 2018).

Finally, after forming an upright stance, the practitioner steps the right foot forward into a diagonal front-right stance, returning to the original position. Similar to point (a), here, the movement of the right foot forms a 90° or right angle (c). This occurs because the right foot, initially in the back-right diagonal position, moves to the front-right diagonal position. Kristanto (2017) notes that the zig-zag pattern in martial arts enables the practitioner to deceive opponents with quick directional changes, while also introducing the concepts of angles and directional shifts in geometry. Kristanto further found that this zig-zag pattern can be used as a method for understanding angles in contextual mathematics education.

c. *Pola Langkah Tupang Tigo Suduik* (Triangle Pattern)

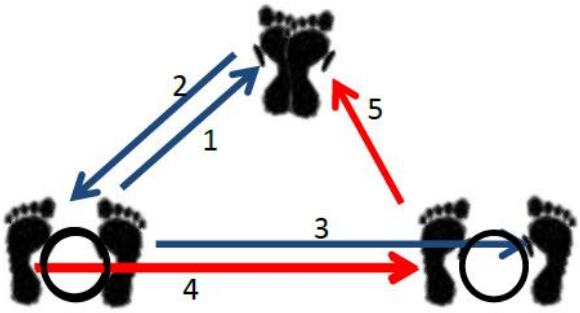

Figure 7. *Tupang Tigo Suduik*/Triangle Step Pattern

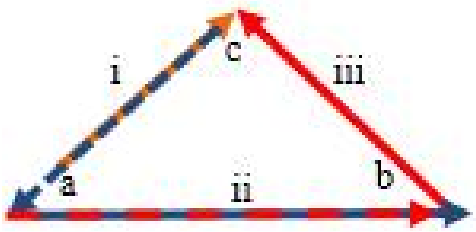

Figure 8. Ethnomathematics Findings in the *Tupang Tigo Suduik*/Triangle Step Pattern

This footwork pattern begins from an upright stance. The practitioner first steps forward with the right foot into a front stance, diagonally to the front-right. Then, the right foot is returned to its original position. Next, the practitioner lifts the right foot to the right side, forming a middle stance. This

is followed by the left foot stepping inward until both heels meet, returning to an upright position. Finally, the left footsteps into a front stance diagonally to the front left.

Stances in Pencak Silat represent the static positioning of both feet (Aryaguna et al., 2017). The diagonal foot movements in the stances form a 45° angle, consistent with the angles created in each direction of the Pencak Silat footwork patterns.

In the *pola langkah tupang tigo suduik*, the foot movements form a pattern resembling an isosceles right triangle. An isosceles triangle is one in which two of the three sides are of equal length and has two equal angles (Emma, 2020).

The formation of this isosceles triangle occurs because in position (a), the movement transitions from the diagonal front-right to the right side. Meanwhile, in position (b), the movement shifts from the left side to the diagonal front left. Therefore, in both conditions (a) and (b), a 45° angle is formed. Since the same stance is used, the distances covered by the foot movements will be equal, making the lengths of the paths in conditions (i) and (iii) the same.

In this pattern, the three sides of the triangle create different angles. Fitriza (2018) found that the triangular pattern reflects the concept of an isosceles triangle, where two sides are of equal length, while one side is shorter. This triangular step is also used to maintain the silat practitioner's strategic position and enhance the efficiency of defensive or offensive movements. According to research by Sari (2022), the isosceles triangle is a common pattern in martial arts movements to help regulate balance and body positioning. In mathematics education, this triangular pattern can be utilized to teach the concepts of symmetry and angles.

d. *Pola Langkah Tupang Ampek Suduik* (Square Pattern)

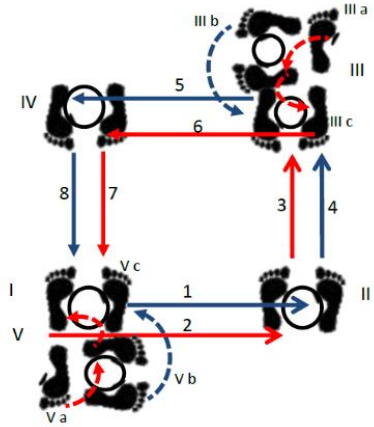

Figure 9. *Tupang Ampek Suduik*/Square Step Pattern

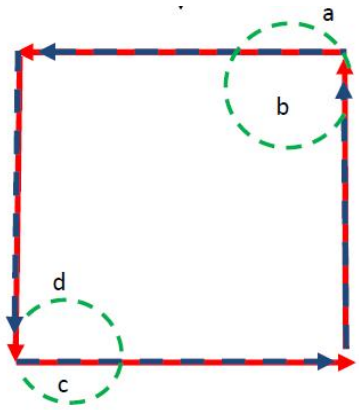

Figure 10. Ethnomathematics Findings in the *Tupang Ampek Suduik*/Square Step Pattern

In the *pola langkah persegi* (square step pattern), we observe that the practitioner performs a rotational movement, with the starting position being the same as the ending position. This pattern combines movements that form both the front stance and the middle stance.

The initial position begins with the practitioner standing upright. They first step to the right with the right foot, forming a middle stance. The left foot then follows until both heels meet. Next, the left footsteps forward into a front stance. Using the left foot as a pivot, the right footsteps toward the left foot, while the left foot rotates 90° on the heel, so that the left foot faces left, and the right foot continues facing forward (a). The right foot then steps to the left, forming a middle stance while rotating the left foot 90° so that both feet and the body face backward (b).

The left foot then steps toward the right foot until the heels meet again, followed by a step forward into a front stance. The right foot then steps toward the right foot, rotating the left foot 90° clockwise (c). When the right foot is about to land, it rotates 180°, bringing the practitioner back to face the front. This is followed by the left foot rotating 90°, returning the practitioner to the upright stance with both heels meeting (d).

In geometry, this pattern reflects the concept of a square, where each corner forms a 90° angle. Violleta explain that the square step provides stability and balance for the practitioner, as the body and feet move in a repetitive pattern with equal angles. The application of the square concept also helps practitioners tactically organize their offensive or defensive movements.

This study demonstrates that Pencak Silat movements, such as the straight, zigzag, triangle, and square step patterns, can be used to teach basic geometric concepts to students. For example, the zig-zag step pattern introduces students to the concept of right angles and intersecting lines. The use of Pencak Silat movements in geometry lessons also provides a contextual and culturally relevant learning experience, enhancing students' motivation to grasp abstract concepts. The integration of local culture

aligns with the principles of contextual learning, which encourages deeper understanding through real-world experiences (Abdullah et al., 2015).

Stances (Kuda-Kuda)

Stances are fundamental techniques in Pencak Silat that help practitioners maintain balance. Each type of stance has a different angle and plays a crucial role in the stability and movement of the practitioner.

a. *Kuda-Kuda Depan* (The Front Stance)

Figure 11. *Kuda-Kuda Depan* (The Front Stance)

Figure 12. Ethnomathematics Findings in *Kuda-Kuda Depan* (The Front Stance)

The front stance (*kuda-kuda depan*) in Pencak Silat is a fundamental technique that plays a key role in maintaining balance and stability. In this stance, the practitioner positions one foot forward, either the right or left, while the other foot remains behind. The body weight leans forward, with the front leg bent at an obtuse angle (between 90° and 180°), while the back leg is straight, forming a 180° angle. The front foot should be perpendicular to the floor to provide a solid foundation. This stance helps the practitioner stay grounded, making it more difficult for an opponent to land a successful attack.

According to interviews with experts, the wider the stance and the closer the body moves toward the ground, the stronger and more stable the stance becomes. In this case, the smaller the angle formed between the back leg and the floor (a), the stronger the stance. This aligns with Fallenius' method, which states that force has an incline angle parallel to the base, with the safety factor being calculated based on the balance of moments. Violleta found that the angle of inclination is inversely proportional to the safety factor-meaning that the smaller the angle, the stronger the stance.

In the front stance, the practitioner bends the front leg at approximately a 90° angle, while keeping the back leg straight. This position provides optimal balance, allowing the practitioner to move quickly forward or backward. Suparman (2016) notes that the front stance is crucial for providing good stability during an attack. It is often used to initiate a direct attack or defend against a frontal assault.

When viewed geometrically, the front stance forms a triangular shape, with the feet at the base and the practitioner's center of gravity at the peak. This stance not only exemplifies the use of angles in martial arts but also highlights the importance of weight distribution, reinforcing the connection between geometric principles and physical stability in combat situations.

b. *Kuda-Kuda Samping* (Side Stance)

Figure 13. *Kuda-Kuda Samping* (Side Stance)

Figure 14. Ethnomathematics Findings in *Kuda-Kuda Samping* (Side Stance)

The *kuda-kuda samping* (side stance) is performed by stepping or sliding one foot to the side. In this stance, one leg is bent, while the other is kept straight, with the body weight leaning toward the bent leg. The key difference between the side stance and the front stance lies in the direction of the body and feet. In the front stance, the feet and body face forward, whereas in the side stance, the bent leg continues to face forward, but the body and the straight leg face sideways.

The side stance is often used to evade an opponent's attack while quickly determining the best counterattack. A proper body inclination occurs when a line drawn from the center of the body (navel) forms a perpendicular line with the bent thigh. If the body leans too far forward (<90°), it can disrupt balance.

In this stance, both legs are bent at smaller angles, typically between 45° and 90°, allowing the practitioner to shift laterally with ease. Santoso (2015) explains that the side stance offers excellent

balance, enabling the practitioner to perform side attacks or evade an opponent's strike. This position also allows the practitioner to quickly redirect an opponent's attack, making it an effective stance for swift movements and counterattacks.

By applying this stance geometrically, the practitioner's bent leg forms an angle that supports optimal weight distribution, facilitating balance and mobility, critical in both offensive and defensive maneuvers.

c. *Kuda-Kuda Belakang* (Back Stance)

Figure 15. *Kuda-Kuda Belakang* (Back Stance)

Figure 16. Ethnomathematics Findings in *Kuda-Kuda Belakang* (Back Stance)

To perform the *kuda-kuda belakang* (back stance), one leg steps backward and bends while the front leg remains straight. The body weight shifts heavily onto the bent back leg, allowing the practitioner to lower their center of gravity and maintain balance. This stance is often used to avoid an opponent's attack, as it helps move the body away from the target area. The more acute the angle formed by the bent back leg, the better the chance of dodging the attack, since the main target area in silat is the torso, from the abdomen to the chest.

By bending the back leg at a smaller angle, the body moves further back and lower, effectively helping the practitioner evade an attack. As the torso is lowered and the body retreats, the practitioner minimizes their exposure to strikes, especially to the upper body, making it a highly effective defensive maneuver.

The geometry of the back stance involves creating an angle between the bent back leg and the floor. A smaller angle results in greater evasion potential, as it increases the distance from the attacker and reduces the target area. This principle aligns with the findings of Fitriza (2018), who noted that a

well-executed back stance offers both stability and effective defense, enabling quick transitions from defense to offense.

In conclusion, the *kuda-kuda belakang* illustrates key geometric principles, where the angle of the back leg is crucial in maintaining balance, lowering the body, and enhancing the ability to evade attacks efficiently.

d. *Kuda-Kuda Tengah* (Center Stance)

Figure 17. *Kuda-Kuda Tengah* (Center Stance)

Figure 18. Ethnomathematics Findings in *Kuda-Kuda Tengah* (Center Stance)

To perform the *kuda-kuda tengah* (center stance), both feet are spread wide, parallel, and aligned with the shoulders, then bent at the knees. In this position, the body and feet face forward, ensuring that the knees are directly above the feet, forming a perpendicular line from the knees to the heels that is straight to the floor. The goal is to maintain a solid, upright posture while distributing the body weight evenly between both legs.

The center stance is used to provide optimal stability, with the body weight balanced equally on both legs. The *kuda-kuda tengah* reflects perfect symmetry, allowing the practitioner to move quickly and efficiently in any direction. This stance also enables the practitioner to defend themselves with great stability without sacrificing flexibility.

By keeping the knees bent and the feet apart, the *kuda-kuda tengah* offers a solid base for both defensive and offensive maneuvers, making it an essential stance for maintaining balance and readiness during transitions in Pencak Silat. The symmetrical position ensures that the practitioner can shift or pivot in any direction, enhancing the flexibility needed for dynamic movements.

Attacks

Attacks in Minangkabau Pencak Silat encompass a variety of movements, including punches, kicks, and elbow strikes. Each movement can be analyzed using mathematical principles to understand the dynamics of force, angles, and motion.

a. Punches

Figure 19. Punching Movement

Figure 20. Ethnomathematics Findings in Punching Movement

In a chest punch, as shown in Figure 19, the arm is extended straight forward, perpendicular to the body, forming a right angle of 90°. Before delivering the punch, there is an initial preparatory movement. Typically, this involves spontaneously drawing the arm back, bending the elbow to form an acute angle. This preparatory movement serves to increase the power and impact of the punch. Additionally, the preparation helps ensure that the punch lands accurately on the target and minimizes the risk of injury.

In Pencak Silat, a punch involves pulling the elbow back to form an acute angle before striking with the arm fully extended at a 90° angle. According to Suparman (2016), delivering a punch with the correct angle allows the practitioner to generate a strong and effective attack. The angle formed during the preparation phase plays a crucial role in determining the power of the punch.

By applying these geometric principles, the proper angles during the punch preparation and execution maximize both force and precision, making the punch more effective in combat situations.

b. Kicks

Figure 21. Kicking Movement

Figure 22. Ethnomathematics Findings in Kicking Movement

In Figure 21, the attack involves a high kick, with the leg lifted until it is parallel with the head. Like punches, kicks also start with a preparatory movement, where the knee is bent and drawn close to the chest. This preparation helps to maximize the power of the kick and makes it easier to direct the kick toward the desired target. When executing a high kick, the angle formed by both legs is obtuse, whereas for a low kick, the angle becomes acute.

In Pencak Silat, kicks are categorized into high and low kicks. High kicks create a larger angle compared to low kicks. According to Santoso (2015), the angle formed during a kick significantly affects the speed and power of the attack. A lower kick offers the advantage of speed, while a higher kick provides greater reach.

Understanding the geometric principles behind these kicks, such as the angles formed and their relationship to speed and power, allows practitioners to optimize their techniques for different combat situations, ensuring both precision and effectiveness.

c. Elbow Strikes

Figure 23. Elbow Strike Movement

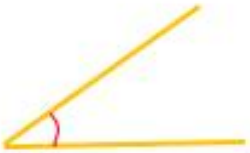

Figure 24. Ethnomathematics Findings Elbow Strike Movement

Elbow strikes (*sikutan*) are a type of attack that uses the elbow as the primary striking tool. To execute this technique, the elbow must be bent to form an acute angle (<90°), allowing the strike to be directed precisely at the target. In Figure 21, the depicted elbow strike is a side elbow strike, accompanied by the use of a side stance (*kuda-kuda samping*) to position the body closer to the target.

The elbow strike is performed with the elbow bent at an acute angle, enabling the practitioner to deliver a powerful attack at close range. That elbow strikes are effective because the smaller angle formed by the elbow increases the force delivered through the strike, making it a highly impactful and deadly attack in close-quarters combat.

This acute angle not only enhances the precision of the strike but also maximizes the transfer of energy, making it one of the most effective techniques for generating power in a limited space. By aligning the elbow angle with body movement, the practitioner can deliver a devastating blow while maintaining balance and stability through the side stance.

Defensive Postures (Sikap Bertahan)

Defensive postures in Pencak Silat include evasion (*elakan*) and blocking (*tangkisan*) techniques, both of which can be analyzed using geometric concepts.

Figure 25. Defensive Posture

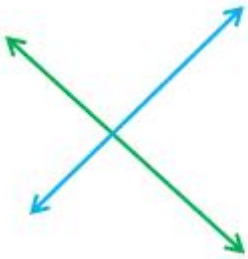

Figure 26. Ethnomathematics Findings in Defensive Posture

Defensive postures in Pencak Silat consist of evasion (*elakan*) and blocking (*tangkisan*). In Figure 23, a type of block known as the upper cross block (*tangkisan silang atas*) is depicted. This technique is used to protect the upper body, especially the head, from an opponent's attack. In the upper cross block, both arms are crossed at a specific point in front of the face, but without obstructing the practitioner's vision. This positioning ensures that the practitioner can still monitor the movements of the opponent while defending. The crossed arms in Figure 23 show the intersection of both hands at one point, forming a protective shield.

Elakan (Evasion) involves avoiding an attack by shifting the body to the side or backward, forming an angle that allows the practitioner to dodge the opponent's strike. According to Wicaksono et al. (2020), this evasive movement creates a rotational pattern that helps the practitioner avoid direct contact with the attack. By positioning the body at an optimal angle, the evasion minimizes exposure and allows for a quick counterattack.

Tangkisan silang atas (Upper Cross Block) involves crossing both hands in front of the face, forming an intersecting angle that balances defense with visibility. Kristanto (2017) states that this technique creates a strong defensive structure, enabling the practitioner to protect the head from attacks while maintaining visual control over the opponent. The geometric intersection of the hands at a single point ensures that the practitioner's defense is concentrated on the most vulnerable area-the head-while allowing for flexibility in movement and counterattacks.

Both defensive techniques rely on geometric principles, with the *elakan* involving angular displacement to avoid attacks and the *tangkisan* focusing on precise angles for effective blocking. These concepts help maintain balance, ensure visibility, and enhance the practitioner's overall defensive strategy in Pencak Silat.

CONCLUSION AND RECOMMENDATIONS

Conclusion

This research successfully reveals that Minangkabau Pencak Silat movements encompass fundamental geometric concepts such as angles, parallel lines, and intersecting lines, which can be effectively utilized in contextual geometry learning. The findings indicate that integrating local culture into mathematics education is not only academically relevant but also adds value by increasing student engagement in the learning process. Therefore, this study introduces a new approach to mathematics education through ethnomathematics, based on local culture, particularly Minangkabau Pencak Silat.

Each movement in Pencak Silat reflects geometric principles such as angles, parallel lines, intersecting lines, and geometric patterns, which can be systematically analyzed. By applying ethnomathematics in teaching, students can understand mathematical concepts through a cultural context that is closer to their everyday lives.

This study also demonstrates that Minangkabau Pencak Silat is not only valuable as a martial art but also as a culturally relevant tool for contextual mathematics education. Through the ethnomathematics approach, Pencak Silat can be used as an effective learning tool for geometry, offering tangible and relevant examples for students.

Recommendations

Based on the findings of this research, several recommendations are provided to ensure that these insights can be more widely applied within educational contexts and the development of ethnomathematics. Integrating cultural concepts into mathematics education is essential for providing students with a more relevant and contextual learning experience.

First, the findings of this research can be incorporated into the mathematics curriculum, particularly in geometry lessons. Using Pencak Silat movements as practical examples in the classroom can help students better understand mathematical concepts, which are often perceived as abstract. Incorporating local cultural examples familiar to students will aid in enhancing their comprehension and engagement in learning.

Second, further research is needed to explore the application of ethnomathematics in other martial arts or local cultures across Indonesia. By broadening the scope of study, ethnomathematics can

be applied to various cultural contexts, which in turn will enrich teaching materials and instructional methods in mathematics education.

Third, it is crucial to provide training for teachers on how to integrate local culture, such as Pencak Silat, into mathematics teaching. Teachers who understand how to teach mathematics using a contextual approach will be able to create more engaging and meaningful learning experiences for students. Such training will enhance teachers' ability to use ethnomathematics as an effective teaching tool, improving the overall learning process.

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