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Culturally responsive mathematics education: Utilizing the traditional *Paser* game as a promising context in teaching probability and statistical concepts

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Abstract

Despite the growing recognition of ethnomathematics in enriching student learning experiences, few studies have explored the mathematical content, particularly probability and statistics, embedded within specific indigenous Javanese games. This research addresses this oversight by focusing on the traditional game of *Paser*, an ancestral practice from Yogyakarta, offering a unique empirical bridge between local cultural philosophy and advanced mathematical concepts. The study aims to systematically identify and analyze the representations of probability and statistical reasoning inherent in the *Paser* gameplay. Data were rigorously gathered through ethnographic methods, specifically using participant observation, documentation, and semi-structured interviews with cultural practitioners. The findings demonstrate that *Paser* effectively integrates elements of probability, statistical distribution, and symbolic meaning. A key discovery is the profound link between the Javanese philosophy of *hening-hening* (inner calm) and an intuitive strategic approach to managing statistical variability, showcasing a deep integration of cultural values and mathematical reasoning. These insights highlight *Paser*'s substantial potential as a contextual medium for developing culturally responsive mathematics education. By situating probability and statistics within a familiar cultural practice, this study not only contributes significantly to the ethnomathematics literature but also provides a tested model for strengthening students' appreciation of their cultural heritage alongside their mathematical literacy.

Keywords: Ethnomathematics; Indigenous Game; Javanese Culture; Multicultural Education; Probability and Statistics

Introduction

Mathematics permeates human activity, yet this ubiquity often remains unrecognized as individuals engage in mathematical reasoning within everyday contexts (Nurhasanah et al., 2017). Historically embedded in cultural practices and applied to real-world problem-solving (Muhtadi et al., 2017), mathematics in contemporary schooling frequently emphasizes abstract concepts and procedural formulas, creating a disconnect from students' lived experiences (Aikenhead, 2021). Consequently, many students struggle with conceptual understanding and the application of mathematical principles to authentic problems (Risdiyanti & Prahmana, 2020). Addressing this pedagogical challenge requires reconnecting mathematics instruction with real-life contexts, particularly those grounded in cultural practices, to render mathematics meaningful and contextually relevant for learners.

Ethnomathematics offers a promising approach to bridging this gap between mathematics and culture. D'Ambrosio (1985) introduced ethnomathematics as the study of mathematical practices developed within communities and rooted in cultural contexts. This framework illuminates how cultural values, ideas, and techniques shape mathematical thinking and problem-solving in everyday life. Integrating ethnomathematics into mathematics instruction enables students to engage with mathematics as a contextually situated discipline aligned with their sociocultural reality (Rosa & Orey, 2016; Risdiyanti & Prahmana, 2021). This approach aligns with culturally responsive mathematics education, which connects students' learning experiences to their sociocultural backgrounds, thereby enhancing relevance, comprehension, and engagement (Meaney et al., 2021).

Despite the multifaceted potential of ethnomathematics, probability and statistics remain among the most challenging topics in formal mathematics education (English, 2023). Many students experience difficulty comprehending uncertainty and data interpretation due to instruction overly focused on formulas and symbolic procedures (Friedrich et al., 2024). Yet probability and statistics are intrinsically connected to daily experiences, particularly in traditional games and social activities involving empirical chance calculations and probabilistic reasoning.

Traditional games represent a significant avenue for ethnomathematical exploration. These games encode both local wisdom and mathematical structures amenable to pedagogical application. Research has demonstrated substantial mathematical content within traditional games: Khasanah et al. (2023) identified arithmetic and modular operations in *Congklak*, while probability, statistics, and geometry concepts have been documented in *Jawa Engklek* (Suprojo et al., 2025; Zuhri et al., 2023). Similarly, Amsikan and Deda (2023) revealed geometric and arithmetic principles embedded in *Kaneka* and *Mariam* games from Nusa Tenggara Timur. These findings substantiate traditional games as effective pedagogical media for culturally responsive, contextual mathematics instruction.

However, despite explorations of traditional games across diverse Indonesian regions, the *Paser* game from Yogyakarta remains unstudied. This game holds considerable potential for probability and statistics education, integrating empirical probability calculations, distributional outcomes from sequential trials, and cultural values including fairness, cooperation,

respectfulness, and sportsmanship. This gap necessitates investigation into how ethnomathematical principles embedded in *Paser* can support culturally responsive probability and statistics learning. Therefore, this study addresses the research question: How can ethnomathematical principles within the traditional *Paser* game support culturally responsive probability and statistics instruction? The research aims to: (1) identify probability and statistics concepts embedded within *Paser* as played in Yogyakarta, and (2) examine the cultural values undergirding this traditional game.

Findings are anticipated to contribute twofold: enriching ethnomathematical scholarship with novel insights into *Paser* and providing practical implications for culturally responsive mathematics curriculum development. By illuminating connections between mathematics and culture, this study advances understanding of how probability and statistics instruction can be grounded in local wisdom, culturally responsive pedagogy, and authentic contextual practices.

Ethnomathematics

Ethnomathematics is understood as an approach in mathematics education that integrates cultural elements into the learning process by drawing on mathematical ideas and practices that have developed within a community (Rosa & Orey, 2021). The main purpose of this approach is to make mathematics learning more meaningful and to improve students' understanding (Mania & Alam, 2021). In this sense, ethnomathematics functions as a learning approach that is inclusive and responsive to cultural diversity (Khasanah et al., 2025). Activities related to ethnomathematics include classifying, counting, measuring, designing, building, playing traditional games, and spatial orientation (Rosa & Orey, 2021).

Beyond mathematical knowledge, ethnomathematics also highlights the cultural and philosophical values that continue to influence human life (Mania & Alam, 2021). Therefore, ethnomathematics is not only about mathematical knowledge but also about appreciating the philosophical and cultural values that shape human ways of thinking. In conclusion, ethnomathematics can be seen as the study of how a cultural group understands, develops, and applies mathematical concepts in activities integrated with their cultural practices.

The Traditional Game of *Paser*

Paser, also known as *Paseran*, is a traditional game from Yogyakarta. The main tool in this game is a dart made from a steel wire measuring 18–22.5 cm in length (Dinas Kebudayaan DIY, 2014). The game is played for entertainment and to fill leisure time. The target is a human-like doll, known locally as a *wong-wongan*. In the playing arena, the doll is placed about 8-10 meters from the player, who sits cross-legged, aims, and throws the *Paser* at the target. The parts of the doll's body that serve as targets are the head, neck, chest, abdomen, and lower section, with the head being the highest-scoring point.

This game's name has a clear historical lineage. In modern dictionaries like the Kamus Bahasa Jawa-Indonesia (KBJI) and Kamus Besar Bahasa Indonesia (KBBI), the word *Paser* is linked to *damak*, which is defined as "a game of throwing short arrows at a target." This suggests

that *Paser* is the local Yogyakarta name for a type of dart game that has been part of the modern lexicon.

To trace its roots further, the authoritative 1939 Javanese dictionary, *Baoesastra Djawa* (Poerwadarminta, 1939), provides even deeper insight. In this text, *Paser* has several meanings, including a short spear, a dart shot from a blowgun, and most relevantly, a short arrow-like object that is thrown (*dibalangaké*). Crucially, the dictionary defines the derivative term *Paser-an* as "a *Paser* game, often involving wagers" (*dolanan Paser, nganggo totohan*). This lexicographical evidence from 1939 confirms that the concept of *Paser* as a formal game has existed in the Javanese lexicon for nearly a century, predating oral histories collected from contemporary players and solidifying its status as a significant cultural heritage. This system of varied scoring zones, combined with the element of chance and skill in each throw, makes the *Paser* game an ideal case study for an ethnomathematical analysis of probability and statistics.

Probability and Statistics as Mathematical Foundations Through *Paser*

Probability constitutes the mathematical framework for analyzing random phenomena, quantifying uncertainty, and measuring outcome likelihood (Ross, 2010). Operationally, probability assigns numerical values between 0 (impossibility) and 1 (certainty) to outcomes within a sample space (Walpole et al., 2017). Within educational contexts, probability reasoning develops students' capacity for decision-making under uncertainty and data-informed risk assessment (English, 2023). Statistics, conversely, comprises methodologies for data collection, analysis, and interpretation, encompassing descriptive statistics (data characterization) and inferential statistics (population inferences from samples) (Walpole et al., 2017). Beyond technical aspects, statistics cultivates critical thinking and data-informed decision-making capabilities (Friedrich et al., 2024).

Ethnomathematical perspectives reveal that probability and statistics reasoning develop meaningfully through culturally situated contexts. Rosa and Orey (2016) emphasize that when learners analyze patterns emerging from cultural practices such as traditional games, they connect mathematical concepts to authentic reasoning. This approach aligns with Pratama and Yelken's (2024) findings that ethnomathematical instruction increases mathematical literacy and engagement by anchoring abstract concepts within learners' cultural environments. Furthermore, Batanero et al. (2016) establish that cultural activities provide meaningful contexts for developing probabilistic thinking.

Traditional games encode probability and statistics naturally through experiential engagement. In *Paser*, probability manifests through throw outcomes dependent on player skill, distance, and implements—mirroring the uncertainty-strategy relationship observed in *Engklek* (Zuhri et al., 2023; Suprojo et al., 2025). Statistical concepts emerge through iterative trials: analyzing throw success frequencies and calculating mean scores introduces measures of central tendency and data variability concretely. Through repeated trials and pattern observation, learners experience how statistics functions as an analytical tool for understanding tendencies and distributions emerging from cultural practice.

This study employs probability theory to model outcome achievement possibilities and uncertainty within *Paser*. Simultaneously, statistical analysis illuminates' patterns from empirical game data. Integrating these theoretical perspectives enables examination of how ethnomathematical principles embedded within traditional games can render probability and statistics instruction contextually meaningful and culturally responsive.

Methods

This study employs a qualitative ethnographic design to explore mathematical and cultural dimensions embedded within the traditional *Paser* game. Ethnographic methodology (Spradley, 2016) was selected to provide contextually rich understanding of sociocultural practices. This approach enables systematic observation, interpretation, and description of how mathematical principles manifest and are articulated within traditional game practices. The methodological framework aims to identify ethnomathematical principles within *Paser*, emphasizing probability and statistics concepts alongside their historical and philosophical underpinnings. *Paser* is thus examined not merely as a cultural artifact but as a living repository of locally meaningful mathematical knowledge.

Data Collection

Data were collected through triangulation of three primary techniques: participatory observation, semi-structured interviews, and document analysis. Fieldwork was conducted during August–September 2025 in Kampung Nyutran, Yogyakarta, a community maintaining *Paser* as an active cultural practice. Participatory observation enabled direct understanding of game mechanics, player interactions, and sociocultural contexts. Semi-structured interviews were conducted with three purposively selected key informants: (1) Mr. Yono (pseudonym), a traditional games practitioner providing technical game insights; (2) Mr. Uji (pseudonym), a community elder offering sociocultural interpretation and meaning; and (3) Mrs. Ina (pseudonym), curator at Museum Sonobudoyo, providing historical context and cultural materials. Supplementary documentation including field notes, photographs, videos, and archival materials from Yogyakarta's traditional game collections strengthened source triangulation. This multifaceted approach ensured that interpretations reflected both ethnomathematical dimensions and pedagogical potential for culturally responsive mathematics instruction.

Data Analysis

Collected data comprising field notes, interview transcripts, and supporting documents—were analyzed thematically using procedures adapted from Creswell (2014). Analysis proceeded concurrently with data collection to maintain contextual depth and interpretive rigor. Initial open coding identified primary concepts emerging from game practice. Subsequent axial coding organized codes into categories and themes depicting relationships between game structure, player strategy, and mathematical interpretation. Three principal themes emerged: (1) Uncertainty and Chance, encompassing sample space and event probability; (2) Strategy and

Decision-Making, involving conditional probability and probabilistic estimation; and (3) Patterns and Repetition, incorporating relative frequency and descriptive statistics as summarize in Table 1. Final synthesis integrated findings to characterize *Paser* as an ethnomathematical practice encoding probability and statistics concepts. Continuous triangulation compared observational, interview, and documentary findings to verify interpretive consistency, strengthening internal validity and ensuring authentic cultural representation rather than subjective interpretation.

Table 1. Principal Analytical Themes and Mathematical Concepts in *Paser*

Theme	Description	Mathematical Concepts
Uncertainty and Chance	Game outcomes exhibit unpredictability, emphasizing inherent probability elements dependent on player skill, implement characteristics, and spatial positioning.	Sample space, event probability, and empirical probability
Strategy and Decision-Making	Players utilize experiential knowledge and observational data regarding opponent behavior to estimate possible outcomes and optimize performance.	Conditional probability, probabilistic estimation, and decision-making under uncertainty
Patterns and Repetition	Iterative game sequences and recurring outcomes generate numerical patterns amenable to statistical analysis, revealing distributional regularities.	Relative frequency, descriptive statistics, and distribution analysis

Ethical Considerations

Research authorization was obtained from Universitas Ahmad Dahlan prior to fieldwork. Verbal informed consent was secured from all participants—elders and cultural practitioners preferring verbal agreement—ensuring voluntary participation with full explanation of research purposes, benefits, and procedures. Pseudonyms protect participant confidentiality; identities are not disclosed in publications. The study maintains cultural sensitivity and local ethical standards, ensuring that community knowledge is neither misrepresented nor exploited. Community approval was explicitly obtained, recognizing participants' intellectual property rights and affirming that cultural documentation proceeded ethically, accurately, and respectfully toward local knowledge systems.

Results

The findings of this study establish the traditional *Paser* game as a multivalent phenomenon encompassing both cultural artifact and mathematical practice. Grounded within Yogyakarta's local heritage, *Paser* manifests historical continuity through its distinctive terminology, standardized practice protocols, and codified rules that simultaneously encode implicit mathematical structures. This analysis presents findings organized into two complementary dimensions. The first dimension addresses the historical foundations, sociocultural significance, and philosophical underpinnings of *Paser*, substantiated through lexicographical documentation and ethnographic interviews with key informants who provided informed consent for research participation. All interviews adhered to research ethics protocols, emphasizing informed consent procedures, respect for informant intellectual property rights, protection of local cultural knowledge, and confidentiality of participant identities. The second dimension undertakes ethnomathematical analysis, delineating how probability concepts, statistical principles, and scoring pattern regularities emerge organically within gameplay mechanics. Collectively, these findings illuminate how *Paser* functions simultaneously as pedagogically meaningful mathematical context and authentic cultural practice, demonstrating the viability of ethnomathematical informed instruction for culturally responsive mathematics education.

The *Paser* Game: History, Culture, and Philosophy

Ethnographic observation and interviews with community stakeholders confirm that *Paser* remains an active cultural practice in Yogyakarta, functioning simultaneously as recreational activity and cultural tradition embedding substantial historical and philosophical significance. According to key informants, the game has been established within communities surrounding the Yogyakarta Kraton for at least four to five decades. Historically, *Paser* was predominantly a male activity conducted during evening hours, with children serving as assistants (*kedi* or *cucuk*) responsible for dart retrieval. Contemporary practice now welcomes female and child participation, particularly during community-organized events conducted under adult supervision.

> *"In the past, it was mostly the man who played at night, and the children were just the assistants," said Mr. Uji.*

The game's historical trajectory reveals significant structural transformation. Informants recalled that the game previously accommodated up to 60 players arranged in circular formation; however, this configuration was prohibited in 1999 due to safety concerns. Since 2022, community-led revival efforts have restructured the game into a semi-circular format accommodating 5–10 players per round. The current regular player base comprises adult men aged 30–60 years, representing continuity of historical tradition while adapting to contemporary safety and community standards.

Beyond recreational function, *Paser* embodies significant sociocultural meaning rooted

in Javanese philosophical principles. The prescribed sitting posture—cross-legged (*bersila*)—carries explicit moral significance: children learn respectfulness through mimicking adult players' physical positioning, thereby naturally internalizing social ethics through embodied practice. Within Javanese cultural contexts, the equality of sitting positions reflects the principle of *andhap* asor (humility and respectful deference) and mutual regard regardless of social status. Community leaders emphasized this integrative function: as one informant noted, *Paser* represents *guyub* (communal harmony and collective identity) rather than competitive achievement, with uniform positioning symbolizing social equality transcending hierarchical distinctions.

> *"Paser is a gathering place, not just a competition. Everyone sits on equal terms, there is no caste," said Mr. Yono*

The game encodes multivalent philosophical meanings extending beyond surface mechanics. The target, wrapped in white cloth, represents female honor (*aurat)*, which must be protected from violation; dart impacts symbolize the destructive consequences of that honor being compromised. The belt (*kendit*) adorning both dart and target symbolizes the necessity of self-control for both men and women. As one informant, Mr. Yono, articulated, successful performance requires internal emotional equilibrium: "*When the heart is not calm, the throw will surely miss.*"

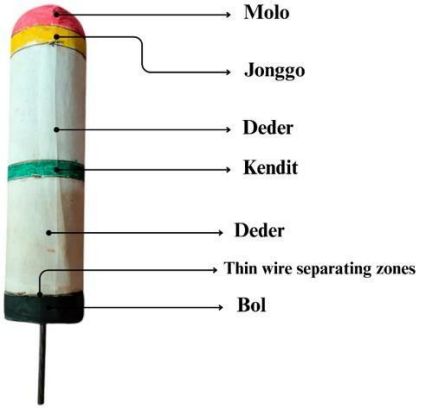
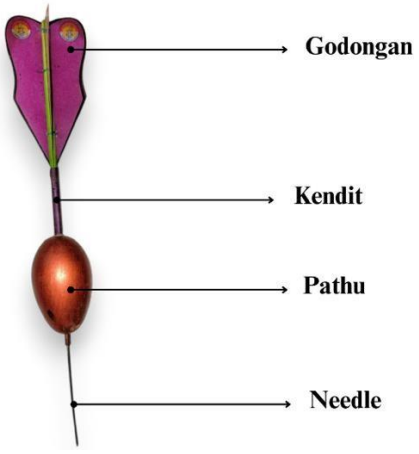
The most emphasized philosophical dimension concerns the player's psychological state. Success in *Paser* depends fundamentally upon achieving *hening-hening* a state of inner tranquility and integrated unity between emotional and cognitive faculties. Erratic throws result from psychological disturbance or fragmented mental states. Community leaders reinforced this emphasis through reference to *roso* (intuitive feeling or visceral knowing) and *panunggaleng roso karso* the unified integration of one's emotional, volitional, and kinesthetic capacities directed toward precise dart guidance. This philosophical framework positions *Paser* not merely as a game of technical skill but as a practice cultivating psychological centeredness, emotional regulation, and the embodied integration of mind, heart, and purposeful action within a sociocultural context emphasizing collective harmony and moral development.

Gameplay and Equipment of *Paser*

The mechanics of *Paser* provide a tangible and dynamic model for abstract mathematical concepts. The primary equipment consists of the dart (*Paser*) and the target (*wong-wongan*). The game's target (*wong-wongan*) constitutes a physical instantiation of a mathematical sample space, as shown in Table 2, encompassing the collection of all possible outcomes resulting from a single throw.

Table 2. Equipment and Gameplay Mechanics of *Paser*

Component	Description	Image Illustration
Arena	The playing arena also affects gameplay. Ideally, the game is played on a soft soil surface, which allows the darts to stick safely and enables a full circular player formation. However, in modern settings without soil, a backdrop is used, which restricts players to a safer semi-circular formation. The evolution and variations of these tools are evident among different practitioners. For instance, the *wong-wongan* targets, though consistently following the zone divisions, show subtle differences in their core material and finishing.	 *Paser* players are aiming at the target.
Gameplay Mechanism	The modern game follows a structured mechanism to ensure fairness and safety. Player positions are determined by lottery, and all players must remain seated cross-legged throughout the round. A typical round is timed for 2 minutes, signaled by a kenong strike, during which players throw as many darts as possible. When time is up, the game ceases immediately. Points are then tallied and exchanged for flags, and the player with the most flags at the end wins.	 Flags of different colors used as scoring markers in a modern *Paser* tournament

Component	Description	Image Illustration
Wong-wongan (Target)	The *wong-wongan* target stands between 170 cm and 180 cm tall and, formerly cored with coconut fronds, now uses softer *sengon* wood to allow the dart to stick more easily and is designed to rotate upon impact, presenting a dynamic challenge. The *wong-wongan* target is typically wrapped in white cloth and divided into distinct colored scoring zones: *Molo* (red, head), *Jonggo* (yellow, neck), *Deder* (body, white), *Kendit* (belt, green), and *Bol* (bottom, black).	 A detailed view of the *wong-wongan* target  Variation in *wong-wongan* design, showing a modern version (left) and a more traditional version from Mr. Uji's collection (right)
Paser (Dart)	Similarly, the *Paser* dart is composed of several key parts: the body (*pathu*), fins (*godongan*), and a needle. The *pathu*, once made from wax or tortoise shell, is now typically crafted from durable *sawo* or *sonokeling* wood. Its *godongan* have transitioned from paper to sturdy mica or Instax film, and its needle from piano wire to bicycle spokes. While its design allows for personal preference, its dimensions are regulated in tournaments, with the main body	 A detailed view of a *Paser* dart

Component	Description	Image Illustration
	(*pathu*) having a maximum diameter of 5 cm to ensure fairness.	
Paser Variations	Furthermore, the *Paser* darts themselves exhibit diverse craftsmanship and material choices across different collections.	 An array of *Paser* darts from Mr. Uji's collection  A set of *Paser* darts from Mr. Yono's collection
The *wong-wongan* target with its supporting stand	The game's target is a physical representation of a mathematical sample space	 The *wong-wongan* target, including its supporting stand

The Target as a Sample Space

Each color-coded zone on the target represents a distinct outcome: *Molo* (head, red), *Jonggo* (neck), *Deder* (body, white), *Kendit* (belt, green), *Bol* (bottom, black), and *miss* (no contact). The sample space S can be formally expressed as:

$$S = \{Molo, Jonggo, Deder, Kendit, Bol, Miss\}$$

This representation indicates six possible outcomes within a single throwing trial. Within probability theory, the likelihood of an event is determined by the fundamental formula:

$$P(A) = \frac{n(A)}{n(S)}$$

where $P(A)$ represents the probability of event A occurring, $n(A)$ denotes the number of favorable outcomes for event A, and $n(S)$ represents the total number of possible outcomes in the sample space.

For example, if a player targets the head zone (*Molo*), the theoretical probability under idealized conditions is:

$$P(Molo) = \frac{1}{6}$$

This calculation assumes that all target zones possess identical area and equivalent difficulty levels, yielding one favorable outcome among six equally likely possibilities. In actual gameplay contexts, however, target zones exhibit substantial variation in both spatial area and difficulty of access. The head zone (*Molo*) occupies considerably less surface area than the body zone (*Deder*), and zones requiring greater precision demonstrate systematically lower success rates than larger zones. Consequently, theoretical probability calculations based on equal likelihood assumptions prove inadequate for characterizing realistic *Paser* performance. An empirical probability approach derived from systematic observation of actual throwing outcomes across repeated trials provides more ecologically valid analysis capturing the authentic probability structure inherent in traditional gameplay.

The Throw as a Probabilistic Trial

Each throw of the *Paser* can be modeled as a probabilistic trial. The outcome of this trial is not purely random but is influenced by multiple variables, including the player's skill and psychological state. The philosophical emphasis on *hening-hening* and *roso* can be interpreted as an intuitive cultural practice aimed at controlling these variables to increase the probability of a desired outcome.

Player strategy can be formally modeled using the concept of Expected Value ($E(X)$), which calculates the average score a player can anticipate per throw. The expected performance of a player per pitch can be represented mathematically as:

$$E(X) = \sum_{i \in S}^{n} x_i P(x_i)$$

This formula quantifies player strategy by weighting the score of each zone (x_i) with its estimated probability ($P(x_i)$), capturing the strategic dilemma between high-risk, high-reward shots and safer, lower-scoring ones.

This activity naturally illustrates the concept of empirical probability, which is derived from the actual outcomes of repeated trials rather than theoretical assumptions. Empirical probability is calculated based on the observed data collected during gameplay. In the context of the *Paser* game, each throw is regarded as one trial that results in one of several possible outcomes—hitting the *Molo*, *Deder*, *Bol*, *Kendit*, or Miss (no hit) zones. After a number of throws, the frequency of each outcome can be used to estimate the empirical probability of each event.

The fundamental formula for empirical probability is expressed as follows:

$$P(A) = \frac{f(A)}{n}$$

where A is an event (for example, a throw hitting the *Molo* zone), $P(A)$ is the probability of event A, $f(A)$ is the frequency of event A occurring, and n is the total number of trials conducted.

As an illustrative example, consider a training session in which a player performs 50 *Paser* throws at the *wong-wongan* target. The recorded outcomes are presented in Table 3.

Table 3. Illustration of *Paser* Throw Outcomes

Target Zone	Frequency of Throws (f)
Molo	4
Jonggo	1
Deder	6
Kendit	2
Bol	3
Miss	34

Accordingly, the empirical probabilities for each zone can be calculated as follows:

$$P(Molo) = \frac{4}{50}, P(Jonggo) = \frac{1}{50}, P(Deder) = \frac{6}{50},$$

$$P(Kendit) = \frac{2}{50}, P(Bol) = \frac{3}{50}, P(\text{Miss}) = \frac{34}{50}.$$

The results indicate that the probability of missing the target (Miss) is the highest at 0.68, while the probability of hitting the head zone (*Molo*) is only 0.08. The results indicate an unequal probability distribution, in which failure (Miss) events predominate. This phenomenon reflects the inherent uncertainty present in real-world situations, which also serves as the conceptual foundation of probability theory in statistics. These probability values lie within the interval [0,1], since probability values cannot be negative or exceed one. Overall, the empirical data from the *Paser* game indicate a non-uniform probability distribution across the target zones, reflecting both the element of uncertainty and the dependence on the players' skills within the game.

The Scoring System as a Probability Distribution

The rules of the game assign a numerical value to each outcome, creating a probability distribution. The findings show significant variations in this system, as summarized in Table 4. In both systems, different outcomes have different values and, crucially, a different likelihood of occurring based on the zone's size and location, making it a non-uniform probability distribution.

Table 4. Comparison of *Paser* scoring systems according to key informants

Target Zone	Score (Yono's Version)	Score (Uji's Version)
Molo	+5	+2
Jonggo	+3	(none)
Deder	+1	+1
Kendit	+2	(none)
Bol	-1	-1
Miss	0	0
Sandang	Bonus Points	Bonus Points

After each round, points are tallied and exchanged for flags—typically at a rate of one point per flag. *Sandang* is a bonus point awarded when a player successfully lands multiple darts in high-value zones in a single turn. A key feature of the scoring is the *Sandang* bonus, which rewards players for landing multiple darts in a single round. According to Mr. Uji, this bonus is calculated based on the number of successful hits. For instance, landing two darts (e.g., one in the *Molo* and one in the *Deder*) earns a +1-bonus point on top of the initial scores. The bonus increases with more hits: three successful darts earn a +2 bonus, four darts earn a +3 bonus, and so on. This bonus system introduces a layer of strategic depth, encouraging players not just to aim for single high-value shots, but to achieve consistency across multiple throws.

It is important to note that while the *Molo* and *Deder* zones are fundamental to the game, the inclusion of the *Bol* zone (with its negative penalty) is often optional and subject to the mutual agreement of the players before a game begins. This highlights the adaptive nature of the game's rules within the community.

A Game Session as Statistical Data Collection and Mean Score

A standard 2-minute round of *Paser* functions as an act of data collection, forming a rich dataset from the scores of one or more players. This data can be analyzed using descriptive statistics. From these data, descriptive statistical measures such as the mean, mode, and range can be calculated. To illustrate how this data can be analyzed, observational data were collected during a hypothetical 10-minute *Paser* game session. The frequency of hits and the resulting scores, based on Mr. Uji's scoring system (*Molo* = +2, *Deder* = +1, *Bol*=-1), are presented in Table 5.

The mean value is computed using the following formula:

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$$

This provides a powerful metric for assessing performance by summing the scores of all individual throws (x_i) and dividing by the total number of throws (n), transforming the qualitative experience of playing into a quantifiable result.

Table 5. Observational data of *Paser* game session (10 minutes)

Scoring Zone	Score per Hit (Points)	Frequency of Hits	Total Score Contribution
Molo	+2	7	14
Deder	+1	21	21
Bol	-1	5	-5
Miss	0	17	0
Total		**50**	**30**

Based on this dataset presented in Table 5, where total points = 30 from 50 throws:

$$\bar{x} = \frac{30}{50} = 0{,}6$$

The data indicate that the mean score per throw is 0.6 points. In other words, from a total of 50 throws conducted over a 10-minute game session, the player accumulated 30 points. This analysis can be further extended using additional descriptive statistical measures such as mode and range, to provide a more comprehensive understanding of the distribution of game outcomes.

The mode represents the value or category that occurs most frequently within a dataset. Based on the empirical data presented in Table 5, the zone with the highest frequency of hits is *Deder*. Therefore,

$$\text{Mode} = \textit{Deder}.$$

The range (R) describes the difference between the highest score ($X_{\max}$) and the lowest score ($X_{\min}$) within a distribution. The range is calculated using the following formula:

$$\text{R} = X_{\max} - X_{\min} = 2 - (-1) = 3$$

A range value of 3 indicates a relatively wide variation in scoring between the highest-value zones (*Molo*) and the penalty zones (*Bol*). Thus, the *Paser* game can be mathematically modeled as a stochastic data collection process, where each throw represents an independent trial contributing to an overall dataset. Through the application of descriptive statistical measures—mean**,** mode**,** range, and probability distribution—the game's outcomes can be systematically analyzed and interpreted within a mathematical framework.

The distribution of hits across scoring zones can be visualized in the following bar chart as shown in Figure 1.

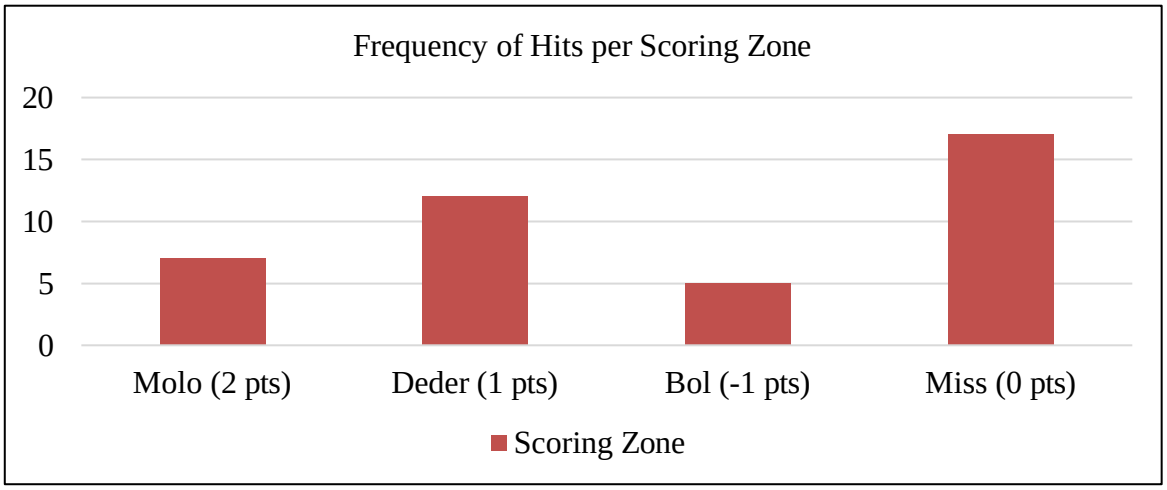


Figure 1. A Bar Chart Showing the Frequency of Hits Per Scoring Zone

Discussions

This study establishes that *Paser* functions as more than recreational practice; it constitutes a cultural expression integrating probability, statistics, and Javanese philosophical values. Prior ethnomathematical research has documented mathematical concepts within traditional Indonesian games: *Congklak* incorporates arithmetic and modular operations (Khasanah et al., 2023); Kaneka and Mariam encode geometric and arithmetic reasoning within cultural contexts (Amsikan & Deda, 2023); and *Engklek* embodies geometry and probability concepts through spatial reasoning (Zuhri et al., 2023). This investigation extends that literature by identifying how *Paser* uniquely integrates uncertainty quantification, probabilistic reasoning, and empirical data analysis through target-based throwing mechanics.

The most significant finding concerns the profound integration between Javanese philosophical principles and intuitive probabilistic thinking. The emphasis on *hening-hening* (inner calm) and *roso* (visceral feeling or intuition) transcends cultural belief to represent a pragmatic strategy for achieving consistent performance. Players recognize experientially that concentration and emotional equilibrium directly influence throw accuracy, thereby reducing randomness and enhancing precision. This phenomenon reveals that cultural values fundamentally shape mathematical reasoning in practice, challenging dichotomies separating culture from cognition or affect from mathematical thinking.

Critically, players develop probabilistic reasoning through repeated engagement without formal theoretical instruction. This finding demonstrates that probabilistic conceptualization emerges naturally within cultural practice, developing tacitly through embodied experience. Players intuitively recognize sample spaces (the six target zones), implicitly estimate outcome likelihoods based on zone accessibility, and implicitly adjust strategy based on observed frequency distributions. The integration of spiritual and emotional dimensions—particularly the belief that inner equilibrium influences dart trajectory—expands conventional understanding of probability beyond numerical abstraction, positioning it as inseparable from psychological and cultural balance.

Beyond mathematical content, *Paser* manifests substantial sociocultural and moral significance relevant to character education. The game instantiates values including communal harmony, fairness, responsibility, patience, and sportsmanship. Communal values emerge through mutual support and equitable turn-taking, establishing *Paser* as a social space strengthening community bonds. Fairness manifests in transparent score recording without manipulation; responsibility appears in equipment maintenance and turn adherence; patience and sportsmanship characterize acceptance of outcomes and appreciation for opponents' successful attempts.

The prescribed cross-legged sitting posture (*bersila*) carries profound ethical significance beyond technical function. This positioning mandates physical equality—no player elevated above others embodying the Javanese principle of *andhap* asor (humility and mutual respect regardless of social status). Children naturally internalize equality and disciplined deference through postural mimicry of adult players. Disputes resolution through communal deliberation reflects local democratic values and justice principles. These observations align with Dharmamulya's (1992) characterization of traditional games as mechanisms for sociomoral formation, wherein values including justice, patience, and honesty are practiced organically through gameplay.

From an educational standpoint, *Paser* addresses a fundamental challenge in mathematics instruction: students' difficulty connecting abstract concepts to daily experience (Risdiyanti & Prahmana, 2020). Classroom implementation could engage students in facilitated gameplay, systematic score recording, and data analysis using descriptive statistics. Subsequent discussion of performance improvement strategies would naturally link cultural practice to probability concepts, making mathematics intrinsically meaningful rather than externally imposed (Nursyahidah & Albab, 2021; Rosa & Orey, 2021).

Pedagogically, *Paser*-based instruction could scaffold probability and statistics learning. Students might construct frequency tables from throw data, calculate empirical probabilities for each target zone, and examine how zone accessibility influences outcome distributions. Reflective discussion examining consistency factors, randomness sources, and strategic optimization would strengthen mathematical reasoning while cultivating cultural appreciation and cooperative values as integral to mathematics education.

This qualitative ethnographic study provides rich contextual description within Yogyakarta's specific cultural milieu but lacks quantitative performance analysis. Future research should conduct statistical comparison of novice versus expert player scoring to quantitatively model skill effects on probability distributions. Additionally, empirical classroom studies should test effectiveness of *Paser*-based learning modules on student mathematics outcomes and cultural engagement.

Comparative ethnomathematical research could examine traditional target or dart games across Indonesian regions, identifying similar or contrasting mathematical structures. Finally, interdisciplinary investigation could analyze *Paser* from physics perspectives—examining dart aerodynamics and parabolic trajectories—to model interactions between physical design, throwing technique, and optimal performance optimization.

Conclusion

This ethnomathematical inquiry into the *Paser* traditional game firmly establishes it as a rich source of embedded mathematical knowledge, contributing significantly to the literature on the cultural origins of statistical and probabilistic concepts. The analysis of the game's inherent mechanics, scoring system, and operational rules explicitly demonstrates concrete representations of fundamental concepts, including sample space construction, probability distribution, and the calculation of statistical means. Furthermore, a central finding of this research is the articulation of a novel connection between the Javanese philosophical concepts of *hening-hening* (inner calm or sustained focus) and *roso* (intuitive judgment) with strategic reasoning regarding statistical variability and consistency. This linkage serves to empirically challenge the traditional compartmentalization of cultural knowledge and formal mathematical thinking, underscoring the necessity of an integrated approach in understanding mathematical cognition within a local context.

Finally, this study acknowledges several limitations that warrant consideration. The ethnographic data were restricted to cultural practitioners within a specific region of Yogyakarta, limiting the generalizability of the findings to other Javanese or Indonesian contexts. Moreover, the research primarily focused on identifying and theoretically articulating mathematical concepts embedded in the *Paser* game, without conducting empirical intervention studies to evaluate its pedagogical effectiveness. Future research should therefore design and test instructional modules based on *Paser* to assess its impact on student engagement, conceptual understanding, and attitudes toward mathematics, thereby advancing culturally responsive mathematics education and affirming local knowledge systems.

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Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been covered completely by the authors.

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