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MATHEMATIZING PLAY: AN ETHNOMATHEMATICAL EXPLORATION OF FOLK GAMES IN BICOL PARTIDO, PHILIPPINES

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ABSTRACT

The study of ethnomathematics in folk games holds significant value as it explores mathematical concepts within cultural heritage, contributing to a more inclusive understanding of mathematics. This research focuses on the ethnomathematics of folk games in Bicol Partido, employing a mini-ethnographic design. Key informant interviews with fifteen participants were conducted to gather data, which were subsequently analyzed using content analysis to identify mathematical concepts in the folk games (i.e., taytayan, tubigan, apir-disapir, and sungka). The analysis revealed various mathematical concepts, including numbers and number sense, geometry, patterns, and probability. Educators are recommended to incorporate these concepts into mathematics instruction, utilizing the folk games as culturally relevant and engaging learning activities. By recognizing and appreciating the mathematical aspects of folk games, educators can foster a deeper understanding and engagement with mathematics among students while preserving and celebrating the cultural heritage of Bicol Partido. Teacher training programs should include components on ethnomathematics, equipping educators with the necessary knowledge and skills. Moreover, the researchers encourage collaborative efforts among researchers, educators, and local communities to develop educational materials and resources that seamlessly incorporate the inherent mathematical elements found in these folk games. Further research is needed to explore the impact of these games on student learning outcomes, cultural appreciation, and engagement in mathematics.

Keywords: Bicol Partido; culture; ethnomathematics; folk games; intangible heritage; mathematization

1. INTRODUCTION

Ethnomathematics is an interdisciplinary field that investigates the mathematical practices and knowledge systems embedded within diverse cultural contexts. It recognizes different ways of understanding and engaging with mathematics beyond the traditional perspective (D'Ambrosio, 2016). One intriguing aspect of ethnomathematics research is the study of folk games, which are cultural activities with mathematical elements. Literature has revealed that folk games serve as sources of entertainment and encompass ethnomathematical concepts (Elpidang & Herrera, 2016; Rubio, 2016; Setiyadi et al., 2018; Zayyadi et al., 2018). These concepts are deeply embedded within the gameplay, reflecting mathematical principles and problem-solving strategies inherent in the cultural context in which the games originate. By incorporating these ethnomathematical concepts, folk games offer a unique and enriching experience beyond mere play (Fendrik et al., 2020; Kamid et al., 2022; Roza et al., 2020; Susanti, 2021).

Exploring mathematical concepts embedded within traditional games has yielded valuable insights into their educational potential. Iortser and Abah (2022) discovered a diverse range of ethnomathematical elements, including arithmetic, geometry of shapes, matrices, systems of linear equations, sequences, and probability, within the Nigerian folk game ‘amenama man wankyo’ (dragon fly and stone). Similarly, Elpidang and Herrera (2016) identified mathematical concepts such as combinatorics, probability, and permutation in the Mamanwa game ‘sik’lut’ (stone flipping and catching) in the Philippines. These findings demonstrate that traditional games offer a rich and interactive platform for teaching and engaging students in discussions surrounding these mathematical concepts.

Another study by Setiyadi et al. (2018) examined Indonesian games like ‘engklek’ (hopscotch), ‘dam-daman’ (checkers), ‘gobak sodor’ (block and pass), and ‘bandaran’ (rubber toss). It revealed the presence of geometric concepts such as rectangles, trapezoids, triangles, and circles, highlighting the potential of traditional games to facilitate the learning of two-dimensional figures in primary school, enabling learners to develop spatial reasoning skills and a deeper understanding of geometry.

Furthermore, a study conducted by Susanti (2021) focused on the traditional game ‘tong tong galitong ji’ (five-stage finger challenge) in Indonesia and uncovered ethnomathematical concepts in every game stage. These concepts encompass arithmetic modulo operations, basic mathematical operations, arithmetic sequences, and the concept of probability. Incorporating these mathematical concepts within the gameplay of ‘tong tong galitong ji’ (five-stage finger challenge) showcases its ability to be an engaging and culturally relevant tool for mathematics education.

The Philippines boasts a rich collection of folk games, a heritage passed down through generations and often shaped by the influence of various historical colonizers. Lopez’s (2001) comprehensive work showcases several games from different parts of the Philippines. These traditional activities served as sources of leisure and amusement for our ancestors, preceding the advent of technological marvels like cell phones and computer games.

Within Lopez’s (2001) book, the games are classified as animals participating in man’s games, ordinary games, jokes, trickster games, and formula games. Most of these games operated as team-based activities, creating avenues for enhanced social interaction, strengthening community connections, and even fortifying family ties. Beyond their recreational value, these games are engaging pastimes that stimulate physical, social, and mental abilities (Balite & Robles, 2020; Cepeda, 2019).

In the context of Bicol Partido, the fourth district of Camarines Sur, a treasure trove of folk games can be discovered, owing to its favorable geographical location. Its diverse landscape, which includes upland and coastal communities, leads to a rich culture, including the folk games. These games are intricately woven into the history, traditions, and values of the Partido people, with the narratives of the elders illuminating the significant folk games our ancestors engaged in. Within this wealth of folk games, it becomes imperative to acknowledge the presence of underlying mathematical concepts. Such recognition is vital for comprehensively grasping their cultural significance and unlocking their educational potential.

Few studies have been undertaken on the ethnomathematics of folk games in the Philippines, and no study has been done on the ethnomathematics of folk games in Bicol Partido. Thus, this study was conducted to mathematize or identify the mathematical concepts contained within the folk games of Bicol Partido. By achieving this objective, the study aims to uncover the mathematical richness embedded in Bicol Partido’s cultural practices and contribute to understanding mathematical thinking in this context. The findings of this research will provide educators with valuable insights into culturally relevant learning contents and approaches to teaching mathematics, ultimately bridging the gap between mathematics education and local cultural heritage and fostering a more inclusive and engaging mathematics learning experience.

2. METHODOLOGY

This section details the systematic approach taken to conduct this study, including research design, participants, instruments, procedures, and data analysis.

2.1 Research design

This study employed a qualitative research approach with a mini-ethnographic design. Fusch et al. (2017) defined mini-ethnography as a qualitative design used to describe, explain, and analyze the cultural aspects of a society or group in a short period. This design is suitable for efficiently gathering data about folk games within the study area over a brief span.

2.2 Participants of the study

This study was conducted in the fourth congressional district of Camarines Sur, commonly referred to as Partido. The district is divided into ten municipalities, each comprising several barangays. The study involved fifteen participants from selected barangays, chosen purposively as key informants. These individuals were selected for their extensive knowledge of Bicol Partido folk games and their long-term residency in the district, typically being 50 years of age or older. The study used snowball sampling, starting with initial senior informants and expanding the participant list through their recommendations.

2.3 Research instruments

This study collected the necessary data using field notes and an audio recorder. Field notes were used to document detailed descriptions and reflections of conversations and interactions with the participants. An audio recorder was utilized to capture verbal interactions and conversations, ensuring accurate and comprehensive recordings of interviews.

2.4 Data gathering procedure and ethics

The data collection began with obtaining permission from the municipal mayor to conduct the study. Following that, the researchers approached the barangay heads to assist in identifying potential informants for the study. Once identified, the informants were provided with consent forms, and their voluntary participation was secured. Participants were fully informed about the objectives and nature of the study. Subsequently, the researchers conducted interviews, recording them using an audio recorder. After completing the interviews, the researchers sought input from history experts and returned to the participants to ensure the validity and reliability of the documented games (Creswell & Creswell, 2018).

To prioritize the well-being and safety of participants and researchers alike, minimum health measures were observed during interviews of folk games. Objectivity during the writing of the manuscript was maintained throughout the entire process.

2.5 Data analysis

This study utilized qualitative content analysis to identify mathematical elements within folk games, following the ethnomathematics framework outlined in Table 1. This framework includes the four general questions, which are the heart of ethnographic principles: "Where is it to look?" "How is it to look?" "What is it?" and "What does it mean?" (Alangui, 2010; Pathuddin et al., 2021; Prahmana & D'Ambrosio, 2020; Utami et al., 2019).

The study extracted the mathematical content from four selected folk games using this framework. Three experts in mathematics education subsequently reviewed the resulting mathematical content to ensure correctness and reliability (Creswell & Creswell, 2018).

Table 1: Framework for ethnomathematics study

General questions	Initial answers	Critical construct	Specific activity
Where is it to look	Folk games as the intangible cultural heritage of Bicol Partido	Culture	Talking to individuals knowledgeable about the folk games of Bicol Partido
How is it to look	Investigate the QRS (quantitative, relational, and spatial) aspects in the folk games of Bicol Partido	Alternative thinking	Determining QRS ideas embedded in folk games of Bicol Partido
What is it	Evidence (results of alternative thinking in the previous process)	Philosophical mathematics	Identifying QRS characteristics of Bicol Partido folk games
What does it mean	The significant value of culture and mathematics	Anthropology	Describing the relationship between the two forms of knowledge (mathematics and culture) Writing mathematical concepts found in folk games of Bicol Partido

3. RESULTS

The study explored four folk games in Bicol Partido (i.e., taytayan, tubigan, apir-disapir, and sungka) and found mathematical concepts like numbers and number sense, geometry, patterns, and probability embedded in these games, highlighting the potential for incorporating culturally relevant activities in mathematics education to promote meaningful learning experiences for students.

3.1 Taytayan (three in a row)

Taytayan, a traditional game popular among the people of Partido in the past, could be played indoors or outdoors by two players. The game utilizes a square board measuring 6 to 12 inches, with a cross drawn at the center and two additional lines forming an 'X' that intersect at the very center of the cross (see Figure 1). In instances where the taytayan board is unavailable, players can draw an arena on the floor or ground.

Each participant needs three chips for this game, such as pebbles, pieces of wood, seeds, or bottle caps. The game resembles the well-known tic-tac-toe (Ruderman & Bakst, 1951), with a notable distinction—the taytayan game eliminates the possibility of a draw. The gameplay unfolds in two distinct phases: the 'placement phase' and the 'move phase.'

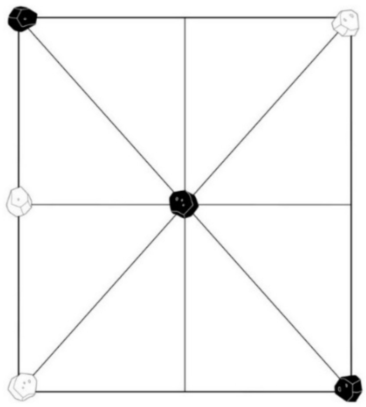


Figure 1: The taytayan board (A player wins the game when the three chips are aligned, representing collinear points)

In the placement phase (see Figure 2), the initial move must be decided upon. The first player, often called the 'mano,' is granted the opportunity to place a chip at any intersecting point within the square. The opponent then follows suit by placing the chip on another point. In this phase, players take turns positioning their chips on the points, strategically aiming to block their opponent, and create a line of three chips (taytay). Should neither player succeed in forming such a line, the game advances to the move phase.

Figure 2: Players, while placing their chips in the placement phase

Transitioning to the move phase, participants maneuver their pieces, intending to arrange a line of three chips. However, it is essential to note that chips cannot be lifted to jump over other pieces; their movement must be continuous from one point to another. The player who arranges three chips in a row wins the game.

Certain geometric concepts are ingrained within the taytayan game that can be utilized in teaching. The taytayan arena, shown in Figure 1, is a valuable tool for illustrating the relationships between squares and triangles and vividly showcases how the diagonal lines of a square inherently form four isosceles triangles. Also, the square can be employed as a visual aid to introduce the area of a triangle.

Likewise, the arena can be employed to illustrate the three undefined terms of geometry, point, line, and plane, including their underlying postulates and theorems. The configuration of arranging three chips consecutively also aligns with the definition of collinear points, wherein three points are considered collinear when they all lie on the same line.

Furthermore, the game also presents a discernible application of probability. Within this context, eight potential winning lines emerge—three vertical, three horizontal, and two diagonal. To ascertain the maximum number of arrangements for six chips (three for each player) on the board during the placement phase, we can employ the permutation formula: $P(n,r) = \frac{n!}{(n-r)!}$, with n representing the total number of objects and r denoting the number of objects selected.

Given that the arena encompasses nine points and six chips, the calculation unfolds as follows: $P(9,6) = \frac{9!}{(9-6)!} = 60{,}480$ possible arrangements of six chips. Consequently, the probability of attaining a winning line can be calculated. This probability is the sum of the probabilities for each winning line: three vertical lines, three horizontal lines, and two diagonal lines. Therefore, the final calculation is as follows:

$$\text{Probability} = \frac{3}{\frac{9!}{(9-6)!}} + \frac{3}{\frac{9!}{(9-6)!}} + \frac{2}{\frac{9!}{(9-6)!}} = \frac{3}{60{,}480} + \frac{3}{60{,}480} + \frac{2}{60{,}480} = \frac{1}{7{,}560},$$ equivalent to approximately 0.013%.

This demonstrates a minimal chance of obtaining three chips in a row during the placement phase. Therefore, players who think strategically about placing and moving their pieces have a better chance of winning the game. Some experienced players of taytayan shared in interviews that they have developed a theoretical pattern to easily win the game, mainly when they are the first players to drop their pieces.

3.2 Tubigan (block the enemy)

Tubigan is one of the most popular outdoor team games enjoyed by our ancestors in Partido. Both boys and girls could take part in this game. A team would typically consist of 4 to 6 players. The game can be played at any time of the day, but it tends to be more popular during moonlit nights.

The game takes place on a level ground with firm soil or a surface covered in cement. The playing field is shaped like a rectangle, marked using water, ash, or a stick on natural ground and chalk or charcoal on cement. Within this rectangle, parallel lines are drawn, while a perpendicular line runs through the middle of each parallel line (refer to Figure 3).

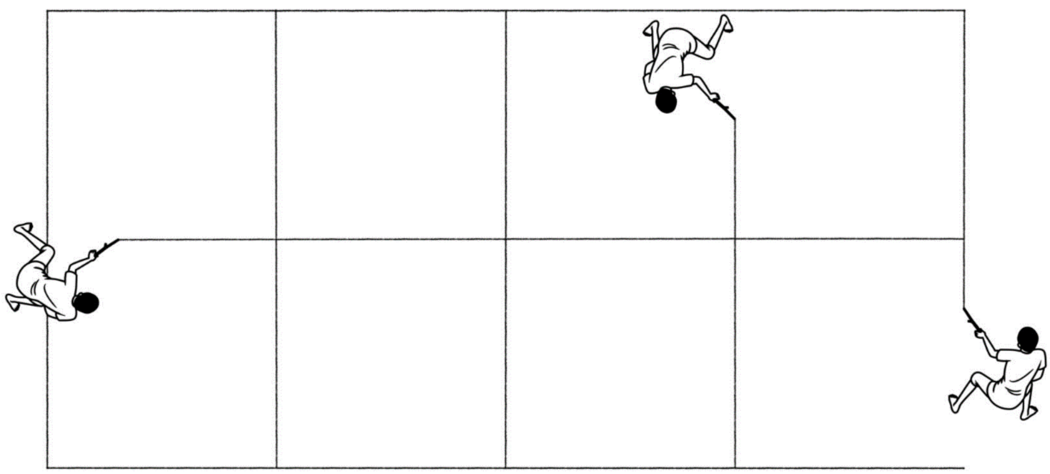


Figure 3: The playing field of tubigan

The rules of this game remain consistent with the tubigan versions found in other regions of the Philippines (Lopez, 2001; Mabborang et al., 2022). The game commences with a coin toss or a round of rock-paper-scissors to determine which team assumes the offensive and defensive roles. The defensive team is called the 'line guards,' while the offensive team is called the 'passers.' The line guards enter the field and assume their designated positions. The team captain is tasked with defending the first line and overseeing the perpendicular line. He can move vertically to tag any opponent attempting to breach the defense.

The game begins with all the passers positioned in front of the captain's line. Their objective is to navigate through all the lines defended by the guard and return to the starting point without falling victim to tagging by the guards. Passers can only be tagged while they are in the process of crossing the line.

The team accumulating the highest points within the agreed-upon time frame wins the game. Points are awarded to passers who successfully cross each line from the entry point to the exit point. The passers commit a foul if they intentionally venture outside the boundary lines to evade being tagged. The penalty for this violation is a change of sides.

The tubigan playing field encompasses the properties of a parallelogram, making it an excellent tool for teaching various parallelogram concepts. Specifically, the playing field utilizes a special type of parallelogram, a rectangle. This geometric layout introduces the idea of a rectangle and facilitates understanding its perimeter and area calculations.

Moreover, the configuration of the playing field is a visual aid for comprehending the concept of parallel lines. The perpendicular line intersecting the parallel lines within the playing field demonstrates a fundamental geometric concept known as a transversal line. This arrangement gives rise to different angles: corresponding angles, interior angles, exterior angles, and supplementary angles. These angle types can be easily introduced utilizing this setup. Also, the crossing between the perpendicular and parallel lines is an illustrative example, shedding light on underlying theorems such as the perpendicular transversal theorem.

Ultimately, the playing field can also illustrate the three fundamental terms in geometry (i.e., point, line, and plane) and the postulates that establish their relationships (see Figure 4). The players' positions throughout the game inherently suggest the concept of a point and the lines used to set the playing field symbolize lines in geometry. The very ground upon which tubigan is played mirrors the plane.

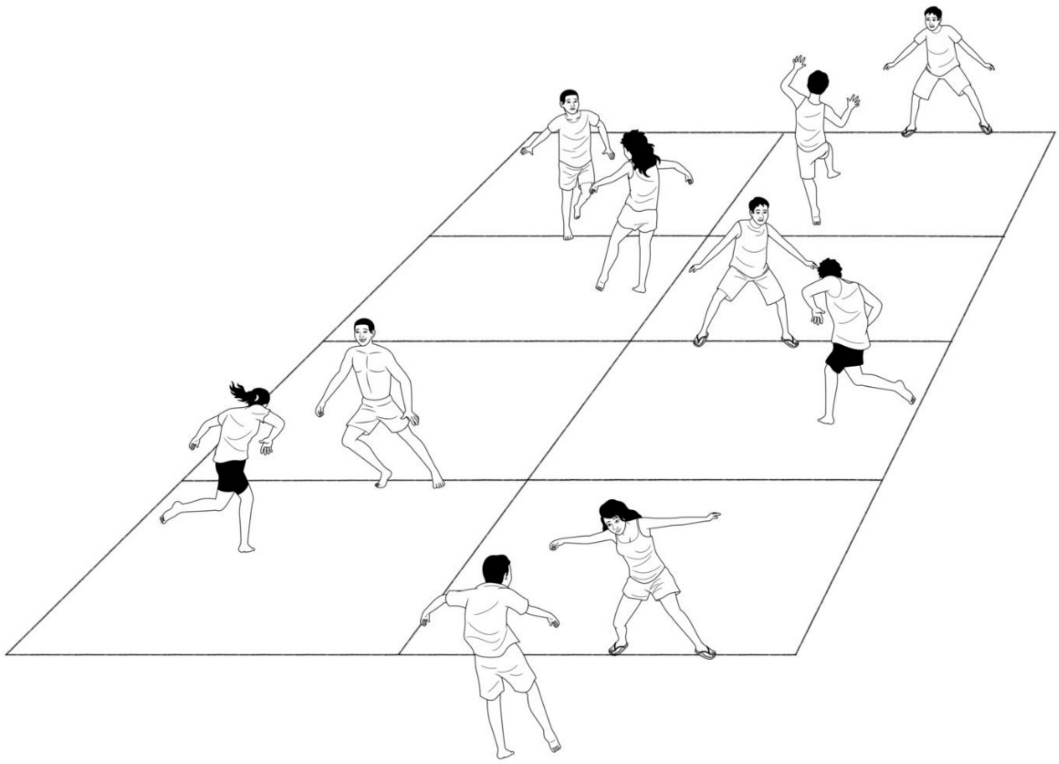


Figure 4: The passers trying to cross the lines

3.3 Apir-disapir (appear-disappear hand positions challenge)

Apir-disapir was a cherished recreational game among children in Partido in the past. It can be played by either two players or a group of more than two players forming a circle. In a two-player game, participants face each other, engaging in a sequence of hand movements while energetically vocalizing the name of each hand position (see Figure 5).

Figure 5: Players can use one or both hands to play the game

The game comprises the following hand movements: 1. apir, 2. disapir, 3. one-half, 4. one-fourth, 5. one-fourth, 6. one-half, 7. disapir, 8. apir (refer to Figure 6 for the hand positions). The initial step of the game resembles the high-five gesture. Players continuously repeat these steps, starting from the first, until one player mistakenly makes an incorrect hand position. The steps are repeated as long as no mistakes are made, and the transition between hand positions gradually accelerates.

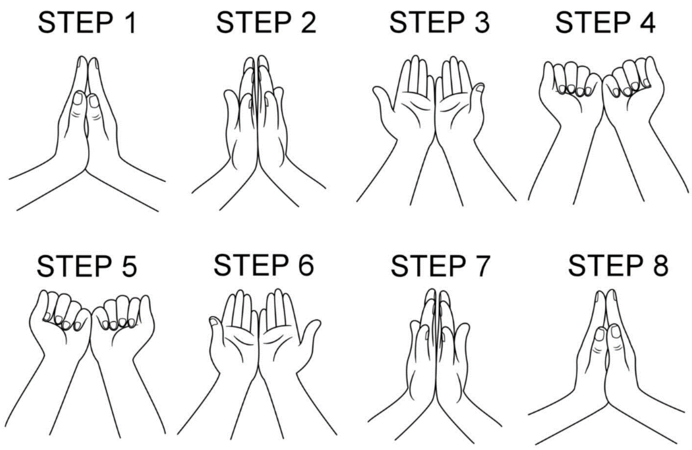


Figure 6: Hand movements of the game

The game incorporates the concept of fractions, specifically featuring hand positions that represent one-half and one-fourth. When both palms are brought together, they represent a circle (see Figure 7). As a result, each player's one-half hand position, characterized by an open palm, symbolizes the fraction ½. Similarly, the one-fourth hand position, where each player forms a closed fist with their palm, represents the fraction ¼.

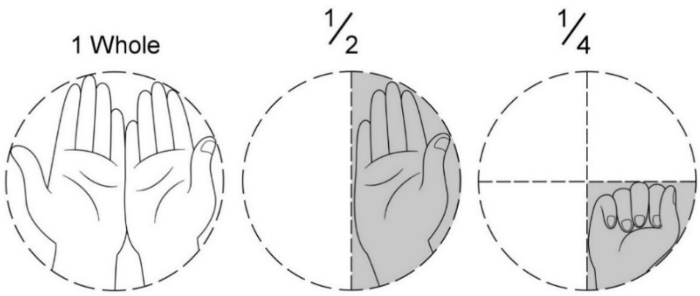


Figure 7: Hand positions for steps one-half and one-fourth representing the fractions ½ and ¼, respectively

In addition, the hand positions from steps 1 to 8 embody the concept of reflection, with each player's hands forming mirrored figures across a symmetrical line. Teachers can leverage these hand positions in the game to introduce the idea of reflection, enhancing the engagement and depth of the discussion.

Finally, the eight steps of this game incorporate a mathematical pattern in algebra, explicitly illustrating the concept of repeating patterns—a pattern that recurs according to a particular rule. As long as no one makes a mistake, the sequence of these eight steps in the game demonstrates the repeating patterns.

3.4 Sungka (board distribution game)

Sungka is an ancient board game that our ancestors used to play, enjoyed by both children and adults. It is a two-player game that gained popularity in Bicol Partido and is widely cherished across the entire country. Sungka is often recognized as the Filipino counterpart of the mancala game, a traditional count-and-capture board game whose origins date back to the seventeenth century (de Voogt, 2010).

The materials needed for the sungka game include a wooden board and small items such as rocks, marbles, seeds, or shells, with cowries being the most commonly used choice. If a sungka board is unavailable or cannot be afforded, players create holes in the ground to mimic the board's layout and use small rocks. The sungka board comprises two rows, each containing seven small holes or pits referred to as 'houses,' along with two larger pits referred to as 'mother holes' or 'heads' on each side (refer to Figure 8). Before the game begins, each player places seven pieces of cowries into each house.

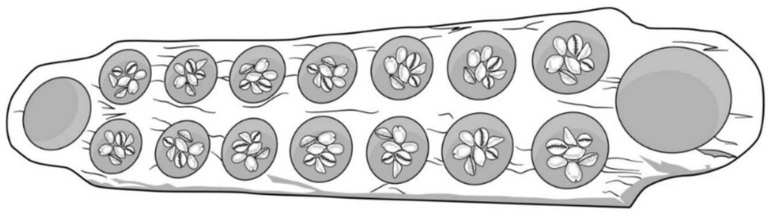


Figure 8: The sungka board

The players sit on either side of the board, facing each other. At the beginning of their first turn, each player collects all the cowries from any of their houses and then distributes one cowry into each hole. Both player A and B distribute their cowries in a clockwise direction (refer to Figure 9). Additionally, each player drops one cowry into the mother hole but skips the opponent's mother hole, distributing the cowries at their own pace. The goal of the game is to accumulate as many cowries in their respective mother holes as possible.

Figure 9: Both players start the game at the same time, putting cowries in their holes, and both player A (the boy) and player B (the girl) move their pieces clockwise

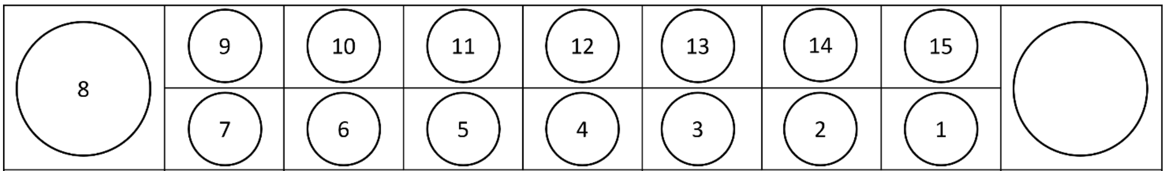
When a player's last cowry goes into his head, they can continue distributing by selecting a non-empty house on their side. If a player drops his last cowry into a non-empty house, he can pick up every cowry in that house, including the one he just dropped, and continue his turn. However, if a player drops his last cowry into an empty house, whether in his own house or his opponent's, his turn ends, and he must wait until it is his turn again to continue. Furthermore, when a player drops a cowry into an empty pit within one of his houses, he can capture the cowries from the corresponding pit on the opposite side and, along with the last cowry, transfer them into his mother hole.

The distribution process continues with players taking turns alternately. The first round concludes when one of the players has no more cowries left in the house. In the second round, the players redistribute their cowries to their houses, filling their pits from left to right with seven cowries per pit. Any insufficiency of cowries to fill another pit must be placed into the player's mother hole. Houses not filled with seven cowries are marked as invalid or burned houses (sulo) and are completely unavailable for the ongoing game, making them unusable for either player. The rounds continue until all of one player's houses are marked as invalid.

The game involves counting numbers. When a player selects a pit to collect cowries for the ongoing distribution, the player meticulously mentally counts the cowries to avoid landing in an empty hole. When the player chooses a hole containing fifteen cowries, the last cowry will return to the same hole from which the player initially took the fifteen cowries. Since this hole is now empty, it means that the player's turn is over. It happens because there are fifteen holes where the player distributes the cowries, constituting one complete rotation in the game.

In cases of more than fifteen cowries at hand or when more than one rotation is required, predicting where the last cowry will land becomes more challenging. In such situations, the concept of modulo (mod) comes into play, another name for the remainder after division. For instance, 7 mod 2 = 1; when you divide 7 by 2, the remainder is 1.

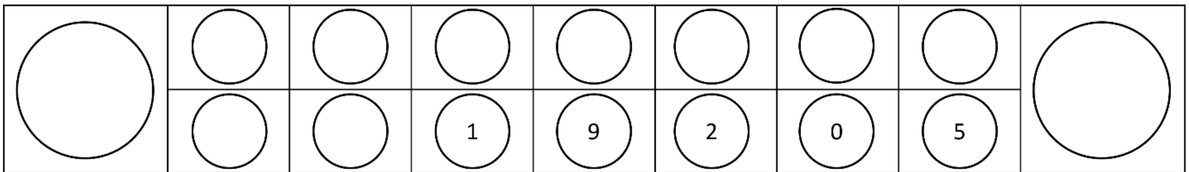
In the sungka game, there is a simple formula to determine where the last cowry will end up: n = mod 15 = r, where n represents the number of cowries for distribution, 15 is a constant representing the total number of holes in one complete rotation, and r is the remainder that indicates where the last cowry will land. For instance, if a player has seventeen cowries for distribution, starting from pit number 7 (as shown in Figure 10), the remainder can be calculated as 17 = mod 15 = 2. This remainder of 2 means that the player should count two pits clockwise from pit number 7, indicating that the last cowry will end up in pit number 9.



n	modulo	The pit number where the last cowry will land
17	17 mod 15 = 2	9
20	20 mod 15 = 5	12
25	25 mod 15 = 10	2
30	30 mod 15 = 0	7

Figure 10: Player A takes a turn by distributing cowries from pit number 7 clockwise

Another fascinating finding about the sungka game is that the placement of cowries on the board aligns with the place value of a digit. According to Manansala (1995, as cited in Vistro-Yu, 2010), the holes on the sungka board each represent a place value. Since there are seven houses in each row, it can be utilized to visualize a seven-digit number, with the place value of each digit arranged from left to right as follows: millions, hundred thousands, ten thousands, thousands, hundreds, tens, and ones. This effectively serves as a place value chart, aiding in identifying both the place value and the value of a digit within a numeral. For instance, Figure 11 illustrates the place value and the value of each digit in the number 19,205.



Place Value	Millions	Hundred Thousands	Ten Thousands	Thousands	Hundreds	Tens	Ones
Value			1 x 10 000 = 10 000	9 x 1 000 = 9 000	2 x 100 = 200	0 x 10 = 0	5 x 1 = 5

Figure 11: The sungka board displays the place value and value of each digit in the number 19,205

Additionally, the sungka board serves as a practical tool for numerical calculations involving whole numbers. Manansala (1995, as cited in Vistro-Yu, 2010) revealed that the sungka board mirrors the traditional paper-and-pencil method of vertically carrying out the four fundamental operations. It offers a visual representation for addition, subtraction, and division of whole numbers, ensuring that the digits are correctly positioned to perform these operations accurately.

For instance, consider the addition of 245 and 723 without regrouping. To illustrate this on the sungka board, first, position the numbers based on their respective place values. In the hundreds place column, place two cowries in the first row and seven cowries in the second row. In the tens place column, put four cowries in the first row and two cowries in the second row. Finally, in the ones place column, place five cowries in the first row and three cowries in the second row. Adding up the cowries in each column results in 968 (refer to Figure 12).

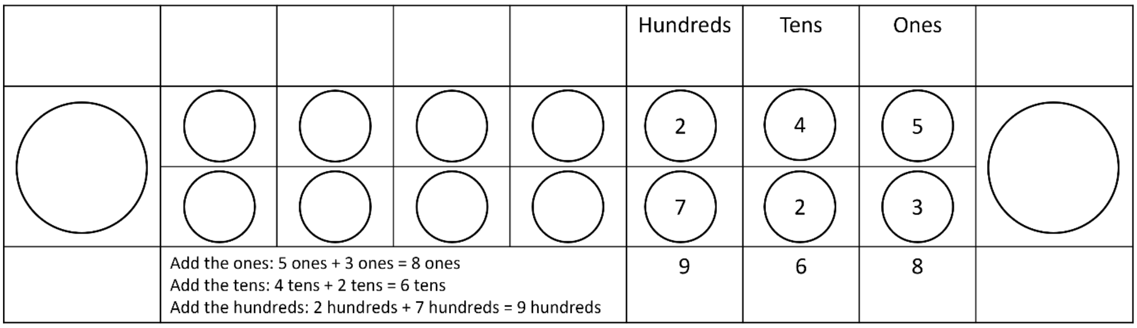


Figure 12: The sungka board shows the addition of 245 and 723 without regrouping

Likewise, the sungka board can be used to illustrate the concept of adding whole numbers with regrouping, which occurs when the sum of any place value column exceeds 9. For example, regrouping becomes necessary when adding 127 and 435 due to the sum of digits in the ones place exceeding 9. As a result, the tens digit of the sum is carried over to the next column while recording the ones digit in the same column (see Figure 13).

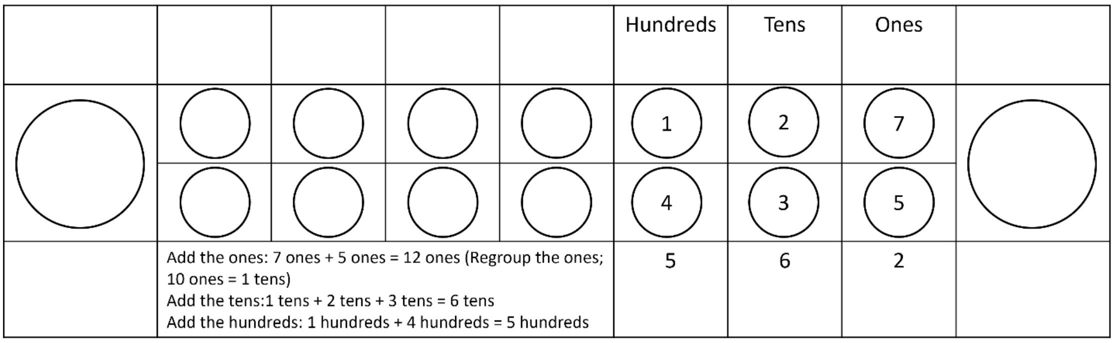


Figure 13: The sungka board shows the addition of 127 and 435 with regrouping

In addition, the game introduces the mathematical concepts of least and greatest. Players compare the number of cowries collected in the mother hole, with the person holding the greatest number of cowries being declared the winner. This game can serve as an effective teaching tool for introducing the concept of comparing numbers, such as using inequality symbols to compare sets of cowries.

Lastly, the game teaches the concept of ordering sets from least to greatest, and vice versa. Teachers can utilize this aspect by placing various numbers of cowries in the first row of the sungka board, allowing students to identify and arrange the set of cowries in ascending and descending order in the second row.

4. DISCUSSION

The research findings shed light on the riches of quantitative, relational, and spatial concepts woven into intangible cultural heritage. These findings contribute to a growing body of literature that explores the mathematical knowledge present in folk games from various cultural contexts.

Based on the findings, spatial concepts emerge prominently in the taytayan and tubigan games, offering valuable opportunities for meaningful integration into teaching geometry. These findings align with previous studies demonstrating geometric elements within folk games (Iortser & Abah, 2022; Roza et al., 2020; Setiyadi et al., 2018; Supahmi et al., 2022). These geometric concepts derived from this intangible heritage can serve as valuable educational resources and be utilized in developing teaching materials for geometry.

Furthermore, the apir-disapir and sungka games intricately integrate mathematical concepts of numbers and number sense. Apir-disapir introduces the notion of fractions through the hand positions during gameplay while sungka's board mirrors a place value chart, facilitating the understanding of place value, arithmetic operations, and number order. Additionally, sungka reinforces basic counting and modular arithmetic, making it a valuable tool for developing number sense. Recognizing the importance of numbers and number sense as predictors of mathematical success (Jordan et al., 2010), educators can employ these traditional games to cultivate these skills effectively. Previous research has supported the effectiveness of folk games in enhancing numerical aptitude among learners (Warmansyah et al., 2021; Wulansari & Dwiyanti, 2021), further underscoring their potential in educational contexts.

Likewise, the taytayan game embodies the concept of probability, with the arrangement and placement of chips on the board as a tangible representation of probabilistic ideas. The findings highlight the educational potential of this game in fostering an intuitive understanding of probability. Literature studies identified the presence of probability concepts within traditional games, illuminating their role as valuable tools for enhancing and developing probabilistic reasoning skills (Elpidang & Herrera, 2016; Supahmi et al., 2022). Recognizing that probability can often be challenging, these insights emphasize the significant role of cultural games such as taytayan in bridging the divide between mathematical theory and practical knowledge, ultimately enhancing our understanding of probability concepts.

Finally, the apir-disapir game demonstrates the concept of patterns as players execute repeated hand positions until a mistake is made. This discovery emphasizes that mathematical patterns can be observed not only in tangible cultural heritage but also within intangible cultural heritage, such as traditional games. This discovery holds significant educational value, particularly for primary-level learners, as it provides a concrete and engaging learning experience in understanding repeating patterns.

The findings of this study offer educational practitioners valuable insights into the potential of cultural practices, such as folk games, as rich sources of learning experiences. Given the cultural richness of the Philippines, particularly in Bicol Partido, which is abundant in cultural traditions due to its diverse geographical landscape, the application of ethnomathematics can significantly enhance students' learning experiences. D'Ambrosio (2016) has highlighted that ethnomathematics is particularly suitable for native populations and is more accessible and affordable, especially for those residing in rural and coastal areas. These findings underscore the universal value of cultural practices as effective mediums for mathematical learning and cultural preservation, bridging the gap between traditional knowledge and contemporary mathematics education (Ascher & D'Ambrosio, 1994; Rosa et al., 2016). By acknowledging and appreciating the mathematical dimensions of folk games, educators can foster a deeper understanding and engagement with mathematics among students while preserving and celebrating the cultural heritage of Bicol Partido.

5. CONCLUSION AND RECOMMENDATIONS

This research on the ethnomathematics of folk games in Bicol Partido has shed light on the diverse mathematical concepts embedded within these traditional games (i.e., taytayan, tubigan, apir-disapir, and sungka). The findings have illuminated the presence of numbers and number sense, geometry, patterns, and probability within these games. Educators are recommended to incorporate these ethnomathematical elements into mathematics instruction, utilizing the folk games as culturally relevant and engaging activities. Teacher training programs should include components on ethnomathematics, equipping educators with the necessary knowledge and skills. Moreover, the researchers encourage collaborative efforts among researchers, educators, and local communities to develop educational materials and resources that seamlessly incorporate the inherent mathematical elements found in these folk games. Such actions would promote cultural preservation and enhance students' mathematical skills and cultural awareness, ultimately creating a more inclusive and holistic learning experience.

6. LIMITATIONS AND FUTURE RESEARCH

Though this research has offered valuable insights, it is important to consider several limitations that point toward potential areas for future investigations. The study was confined to examining only four folk games, with an exclusive emphasis on uncovering the inherent mathematical concepts within each game, omitting any exploration into the origins of the game names. Notably, the researchers refrained from discussing participants' shared winning lines or patterns to maintain fairness and enable future players to independently engage with and appreciate the games. Hence, the researchers did not further explore the mathematical concepts underlying these winning lines or patterns. Additionally, although the researchers unveiled the mathematical potential within these games, they did not empirically investigate their efficacy in teaching mathematics. Consequently, there is a need for subsequent studies to delve into the pedagogical value and educational impact of these games on enhancing mathematics learning.

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