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Unlocking mathematical marvels: Exploring number patterns in the *Rangku Alu* traditional game

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Abstract

Ethnomathematics, an interdisciplinary field at the intersection of cultural studies and mathematics, examines the intricate mathematical practices found within diverse cultural settings. This research focuses on *Rangku Alu*, a traditional game from Indonesia, to explore its embedded mathematical elements. Using a qualitative ethnographic methodology, the study uncovers the mathematical concepts within the game's cultural context. It traces the origins and cultural importance of *Rangku Alu* in Manggarai, East Nusa Tenggara, through combining participant observation, interviews, and literature review. The game, which prominently features bamboo, is a staple activity in harvest celebrations and serves as a way to express gratitude. During the game, players engage in synchronized movements that create rhythmic patterns and interactive sequences. The analysis reveals seven distinct numerical patterns, derived from the strikes of bamboo, jumping sequences, and player formations. These patterns include both odd and even sequences, as well as basic arithmetic operations. *Rangku Alu* not only entertains but also provides a unique setting for exploring numerical concepts. This study highlights the potential of integrating traditional practices like *Rangku Alu* into mathematics education to promote inclusivity and enhance mathematical understanding in multicultural environments.

Keywords: ethnography; ethnomathematics; number patterns; *Rangku Alu* traditional game

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Introduction

Indonesia's cultural landscape is rich with traditional practices, including indigenous games that play a significant role in shaping social cohesion and community values (Hakim, 2011; Agus et al., 2021; Hidayati & Prahmana, 2022). However, with the rapid adoption of technology, these traditional games are becoming increasingly marginalized, especially among the younger generation who are drawn toward digital entertainment (Imran, 2023; Risdiyanti et al., 2024). Despite this shift, traditional games continue to offer intrinsic value, promoting communal bonds, enhancing cognitive skills, and fostering a sense of togetherness within communities (Prahmana et al., 2023). Therefore, Indonesia's traditional games, which foster social cohesion and community values, are facing a decline due to the growing popularity of digital entertainment among younger generations, although they still offer important benefits like promoting community bonds and enhancing cognitive skills.

To address this cultural shift, a novel educational approach has emerged that integrates cultural elements with teaching practices (Risdiyanti & Prahmana, 2020a). Known as ethnomathematics, this approach uses cultural contexts to enhance mathematical understanding (D'Ambrosio & Rosa, 2017; Jabar et al., 2022). Ethnomathematics encompasses the study of mathematical concepts as practiced by identifiable cultural groups, providing a sense of identity and ownership over their mathematical knowledge systems (D'Ambrosio, 1985; Prahmana, 2022). By linking education to cultural practices, this approach has the potential to make mathematics more relatable and inclusive, promoting deeper engagement in multicultural educational settings.

Ethnomathematics explores the unique mathematical practices inherent in various cultural contexts (Rosa & Orey, 2023; Fitriadi et al., 2024). Mathematics, while a critical discipline for developing problem-solving skills, is frequently viewed as intimidating and inaccessible by many (Metz & Davis, 2020). This perception of mathematics as difficult stems in part from a limited perspective that reduces the field to mere numerical calculations, overlooking its broader applications. This sentiment is reflected in Indonesia's results from the 2018 Program for International Student Assessment (PISA) study, which indicated significant gaps in mathematical proficiency. Further reinforcing this trend, Indonesia's recent PISA 2022 results show continued underperformance in mathematics among students (Organization for Economic Co-operation and Development [OECD], 2023).

To combat these challenges, a shift toward learning approaches that are grounded in real-world contexts, like ethnomathematics, is necessary. Ethnomathematics connects mathematical concepts to cultural practices and everyday experiences, making the subject more relatable and engaging for students. By integrating cultural elements into the study of mathematics, educators can foster a learning environment that not only mitigates the fear of mathematics but also aligns with students' lived experiences, potentially leading to improved mathematical understanding and proficiency.

The traditional Indonesian game *Rangku Alu* provides a compelling example of how cultural practices can integrate mathematical concepts. This game, which originated in Manggarai, East Nusa Tenggara, has deep historical roots as a ritual for harvest celebrations,

using bamboo beats to create rhythmic patterns (Tim PlayPlus Indonesia, 2016). Beyond its cultural significance, *Rangku Alu* inherently incorporates mathematical principles, notably in its use of number patterns (Rahmat et al., 2018).

Number patterns are a key component of the junior high school mathematics curriculum, yet many students struggle with this topic, especially when it comes to formulating expressions for the n^{th} term (Risdiyanti & Prahmana, 2020b; Cai & Hwang, 2023). By exploring the traditional game of *Rangku Alu*, educators can offer a tangible and culturally relevant context for understanding these mathematical concepts. The rhythmic sequences and player movements in the game can be used to illustrate pattern recognition, progression, and other mathematical ideas, providing students with a more engaging and intuitive approach to learning.

This study is rooted in the principles of Realistic Mathematics Education (RME), a pedagogical approach that emphasizes the use of real-life situations and experiences as reference points for creating a contextualized and meaningful learning experience (Van den Heuvel-Panhuizen & Drijvers, 2020). Within RME, these real-world scenarios serve as opportunities for learners to construct their understanding of mathematical concepts and processes, fostering a more intuitive and engaging approach to mathematics education.

In addition to RME, the research is also grounded in Ethno-Realistic Mathematics Education (E-RME), a methodology that integrates cultural contexts into mathematics teaching. E-RME underlines the importance of exploring various sociocultural values within the trivium curriculum, thereby creating a richer and more meaningful understanding as students engage with mathematical learning (Prahmana, 2022). By combining these approaches, the study aims to not only make mathematics more accessible and relevant to learners but also to underscore the importance of cultural heritage and diversity in the educational process.

The *Rangku Alu* traditional game exemplifies the symbiotic relationship between culture and mathematics, and this study aims to explore its evolution and implications for understanding number patterns. While delving into the numerical sequences produced by the game's bamboo beats, the research also examines the sequences of player jumps and the dynamics of participants' positions during gameplay. By encompassing these various elements, the study seeks to uncover the underlying mathematical patterns embedded in this cultural artifact.

Through this comprehensive analysis, the research endeavors to demonstrate how cultural practices like *Rangku Alu* can act as conduits for mathematical understanding and pedagogical innovation. By examining the mathematical concepts inherent in this traditional game, the study highlights the potential for culturally grounded approaches to make mathematics more accessible and engaging. The findings could inspire educators to leverage cultural artifacts as meaningful resources in their teaching, ultimately promoting a more inclusive and contextualized approach to mathematics education.

Methods

This study adopted a qualitative approach, aiming to understand specific phenomena or issues from the perspective of individuals or groups (Li & Tsai, 2013; Hung et al., 2018), particularly

in the context of traditional games. A key aspect of this qualitative investigation was its ethnographic methodology (Siraj-Blatchford, 2010; Hockey, 2020; Silverman et al., 2021), which focused on exploring the cultural aspects inherent in the *Rangku Alu* traditional game. By engaging in ethnographic fieldwork, the research sought to immerse itself in the socio-cultural environment of the participants, allowing for a broader and more open perspective on the culture (Fetterman, 2008; Siraj-Blatchford, 2010; Hockey, 2020; Silverman et al., 2021). Furthermore, the study had two primary objectives: first, to investigate the historical and philosophical foundations of *Rangku Alu*, and second, to identify and analyze the presence of number patterns within the game. Through this ethnographic approach, the research aimed to capture the lived experiences and cultural context of the game's participants, providing a deeper understanding of how these traditional practices inform mathematical concepts and contribute to pedagogical innovation.

Data collection for this study comprised a mix of observation, interviews, and examination of the traditional game *Rangku Alu*. Observations involved closely watching children's interactions and gameplay to understand the mechanics and patterns of *Rangku Alu*. This direct observation provided valuable insights into the dynamics and social aspects of the game.

Interviews were a critical component of the data collection process, involving discussions with key informants who have deep knowledge of traditional Indonesian games. Among those interviewed were Ms. Agatha from the *Kolong Tangga* Museum of the *Dunia Damai* Foundation and Ms. Sarita from the Indonesian Children's Traditional Game Preservation Community (Tim PlayPlus Indonesia, 2016). These interviews were designed to capture their insights into the history, cultural context, and significance of *Rangku Alu*, thereby enriching the study's understanding of the game's role in Indonesian heritage and its educational potential.

The data analysis in this study was carried out in two distinct stages: pre-field analysis and field data analysis (Moser & Korstjens, 2018; Tracy, 2019; Pyo et al., 2023). The pre-field analysis stage involved the examination of secondary data and the results of preliminary studies to define and refine the research focus (Moser & Korstjens, 2018). This process helped to identify key themes and formulate specific areas of inquiry for the fieldwork.

Following this, the field data analysis phase included a series of steps: data reduction, data presentation, and drawing conclusions (Tracy, 2019; Pyo et al., 2023). Data reduction involved filtering and organizing the collected information to focus on the most relevant aspects of the study. Data presentation entailed structuring and visualizing the data to facilitate interpretation. Finally, the conclusion stage synthesized the findings, providing a comprehensive understanding of the cultural and mathematical components of the *Rangku Alu* traditional game. This structured approach allowed for a detailed exploration of the cultural and mathematical patterns, contributing to a deeper appreciation of how traditional games like *Rangku Alu* can serve as meaningful contexts for mathematical learning and cultural preservation.

Results

The investigation into the ethnomathematics of the *Rangku Alu* traditional game has revealed a convergence of cultural and mathematical components. *Rangku Alu* represents a distinct genre of traditional games within Indonesia's diverse cultural landscape, which spans from Sabang to Merauke, encompassing a plethora of regional variations influenced by geographic diversity (Tim PlayPlus Indonesia, 2016; Rahmat et al., 2018; Agatha, 2022). Originating from the Manggarai region in East Nusa Tenggara, *Rangku Alu* initially manifested as a bamboo dance imbued with profound philosophical symbolism, serving as a ceremonial expression of gratitude and jubilation for agricultural abundance (Tim PlayPlus Indonesia, 2016; Agatha, 2022). The bamboo itself, referred to as "Alu," symbolizes a rice-pounding implement, thus bestowing the name "*Rangku Alu*" upon the game (Agatha, 2022). However, regional nuances may alter the nomenclature and cultural context of *Rangku Alu*, reflecting variations in local traditions. During harvest festivities in Manggarai, *Rangku Alu* intertwines with other ceremonial dances such as the *Caci* and *Nududu Ndake*, forming an integral part of the cultural fabric and communal rituals observed by the indigenous communities of East Nusa Tenggara (Tim PlayPlus Indonesia, 2016).

The significance of the *Rangku Alu* dance has evolved over time, expanding from its original role as a harvest ceremony to become a popular traditional recreational activity (Sarita, 2023). Both the dance and the game of *Rangku Alu* share common elements, notably the use of bamboo to create rhythmic patterns, often accompanied by singing. However, clear differences have emerged regarding attire and structure. During traditional harvest ceremonies, participants don cultural clothing, and the dance sequences are synchronized with specific songs, often presented alongside other traditional dances such as *Caci* and *Nududu Ndake*.

In contrast, the *Rangku Alu* game has a more flexible format, allowing participants to engage without adhering to a strict ceremonial structure. This game can be played independently from the traditional dances, with participants wearing casual attire and engaging with less physical intensity. Additionally, the songs played during the game are not bound to a specific set and can vary according to individual preferences. This shift from a formal, ceremonial context to a casual recreational activity reflects the adaptive nature of cultural practices. The transformation of *Rangku Alu* into a versatile and accessible pastime has contributed to its continued popularity across communities in East Nusa Tenggara, demonstrating the cultural resilience and adaptability of traditional games.

The gameplay in *Rangku Alu* produces a rhythmic beat through the synchronized movements of bamboo, creating an incidental sequential pattern. This pattern is inherently linked to the rhythm of the accompanying song, as shown in Figure 1. The coordination between the bamboo's beats and the song's rhythm forms a harmonious interaction, which is a distinctive characteristic of the traditional game. This synchronization plays a central role in guiding the participants' movements and maintaining the pace of the game.

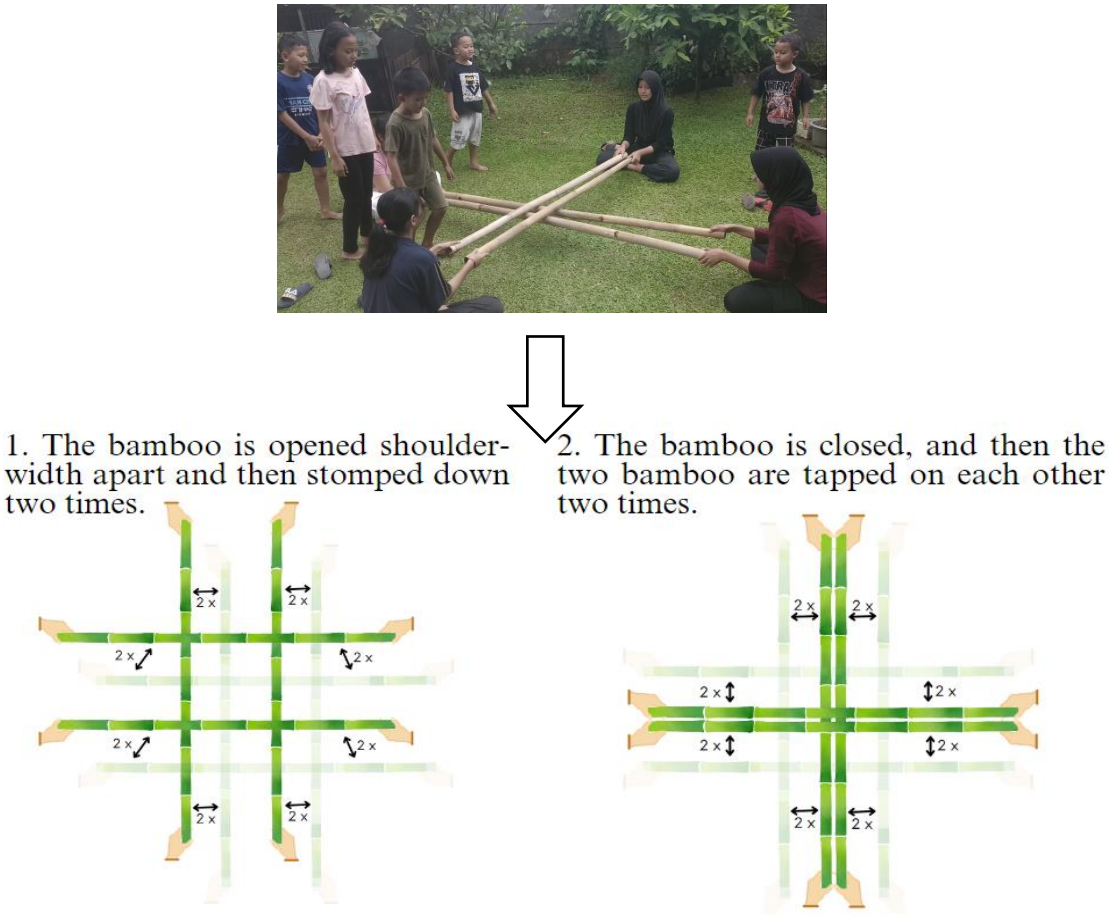

Figure 1. The first number pattern in the *Rangku Alu* traditional game

Playing *Rangku Alu* follows a simple process involving two groups with at least five participants and four pieces of bamboo, each approximately two meters in length (Sarita, 2023). The first group takes on the role of bamboo holders, squatting to form a square and holding two bamboo pieces each. Meanwhile, the second group, which includes at least one jumper, is responsible for the game's jumping aspect. The game begins with the rhythmic movement of the bamboo, where the bamboo holders open and close the pieces in synchronization, typically accompanied by music or traditional folk songs.

The objective for the jumper is to leap over the bamboo pieces following the rhythmic pattern. If a jumper's legs are caught by the closing bamboo or if the musical accompaniment ends, the players can switch roles, allowing others to jump or hold the bamboo. This dynamic requires players to maintain focus and agility, as timing and rhythm are key to successfully navigating the bamboo movements. Consequently, mastering *Rangku Alu* involves a blend of physical coordination, quick reflexes, and an acute sense of rhythm, making it an engaging and culturally rich traditional game.

Figure 1 illustrates a sequential pattern of beats produced by the opening and closing movements of the bamboo in the *Rangku Alu* game. This pattern, represented as 2, 2, 2, 2, mirrors the rhythmic structure of the South Kalimantan regional song "*Ampar-Ampar Pisang*," a traditional tune often sung during the game. The two-beat rhythm in the song aligns with the game's bamboo pattern, guiding the timing and tempo of the opening and closing actions. This

synchronization between the rhythmic bamboo movements and the musical accompaniment creates a cohesive and engaging experience for the players, reinforcing the cultural significance and traditional roots of the *Rangku Alu* game.

Moreover, the versatility of the *Rangku Alu* game allows for the utilization of varying beat patterns, as depicted in Figure 2.

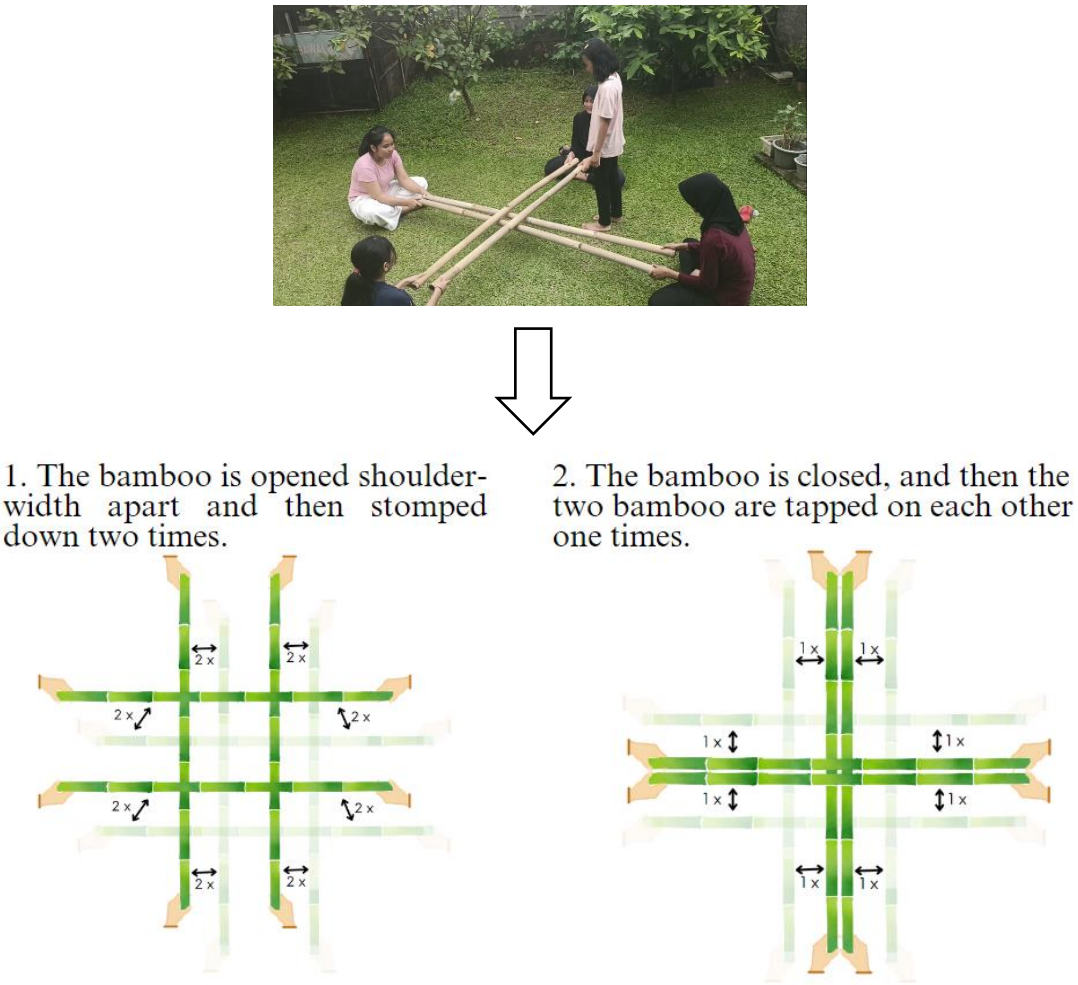

Figure 2. The second number pattern in the *Rangku Alu* traditional game

Figure 2 illustrates a recurring pattern of bamboo movements in the *Rangku Alu* game, depicted as 2, 1, 2, 1, indicating the rhythmic sequence of opening and closing the bamboo pieces. This sequence is frequently associated with children playing *Rangku Alu* while singing traditional Javanese folk songs like "*Gundul-Gundul Pacul*" (Rahmat et al., 2018). The alternating pattern creates a unique tempo that complements the rhythm of these folk songs, contributing to the game's traditional atmosphere. By synchronizing their movements with these sequential patterns, players can maintain the flow of the game while enjoying the cultural connection provided by the familiar melodies.

Beyond the auditory cues provided by the bamboo beats, the established pattern can also be discerned from the rotational order in which players take turns jumping on each bamboo square. The designated jumper navigates the bamboo squares, hopping in sync with the rhythmic opening and closing motions, as depicted in Figure 3.

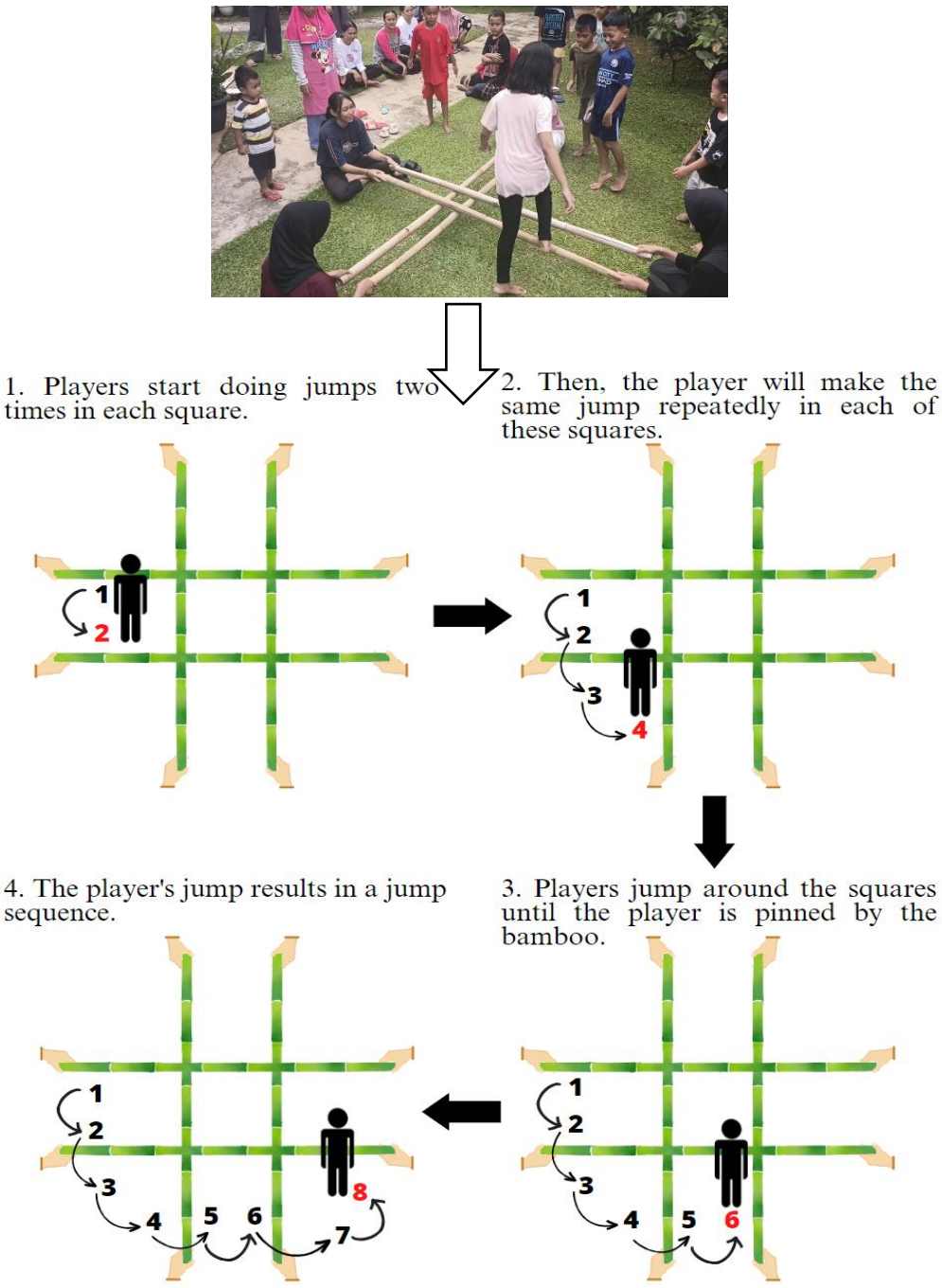

Figure 3. The third number pattern in the *Rangku Alu* traditional game

Figure 3 shows a pattern emerging from the sequential jumps of players in the *Rangku Alu* game, with a cumulative count of 2, 4, 6, and 8. This pattern reflects the total number of final jumps across the bamboo squares, indicating a consistent progression as the game continues. This pattern can be used to explore concepts such as arithmetic sequences and even numbers, providing an opportunity to connect gameplay with mathematical concepts.

In contrast, Figure 4 illustrates another pattern derived from the initial jumps of players on each bamboo square. This distinction between the final and initial jumps allows for different interpretations and analyses, giving insight into various aspects of the game and its

mathematical underpinnings. By examining both patterns, educators and researchers can better understand how traditional games like *Rangku Alu* can embody mathematical principles and serve as engaging tools for learning and exploration.

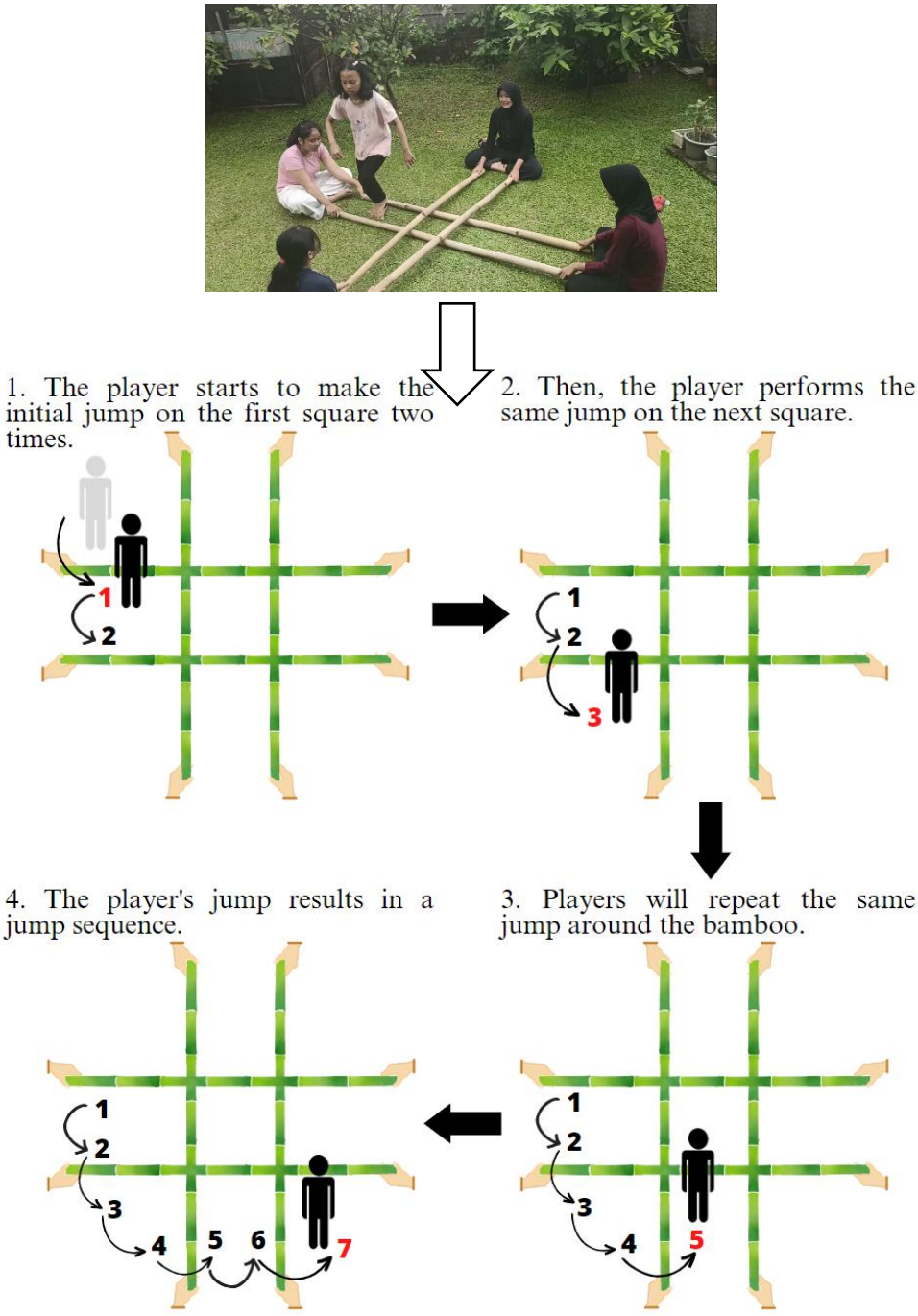

Figure 4. The fourth number pattern in the *Rangku Alu* traditional game

Figure 4 illustrates that the initial jump of players on each bamboo square yields a pattern of 1, 3, 5, and 7 as they traverse through these squares. However, a distinct pattern emerges when the player's position during the initial jump is situated between the bamboo squares held by each bamboo holder, as depicted in Figure 5.

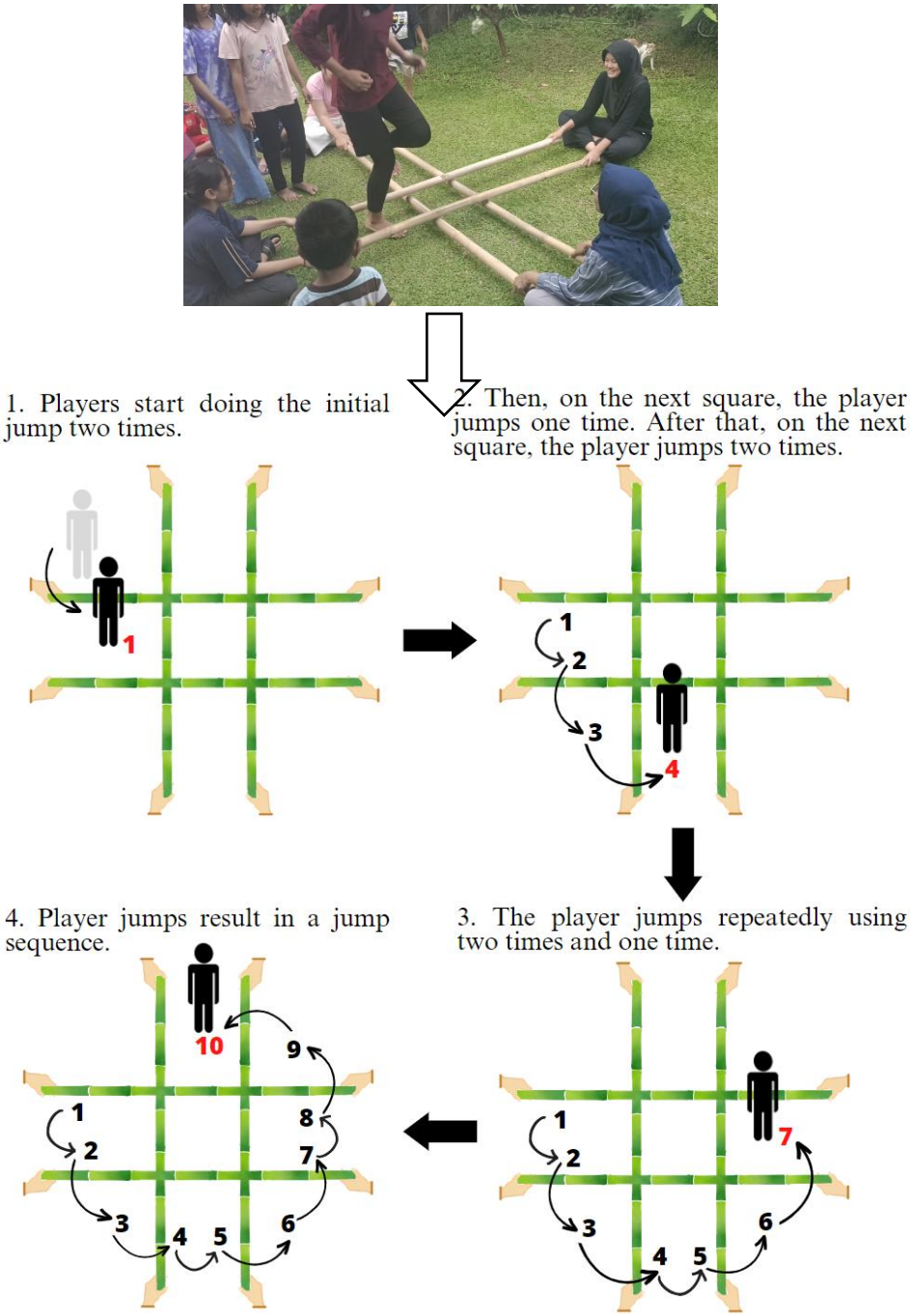

Figure 5. The fifth number pattern in the *Rangku Alu* traditional game

Figure 5 demonstrates the jumper's positional movement based on the jumps' sequence, utilizing the rhythmic beat of one closed bamboo and two open bamboos held by the bamboo holders, resulting in a pattern of 1, 4, 7, and 10. Furthermore, the *Rangku Alu* traditional game can accommodate more than one jumping player simultaneously. In this study, the maximum number of jumpers involved in a game of *Rangku Alu* is four, as depicted in Figure 6.

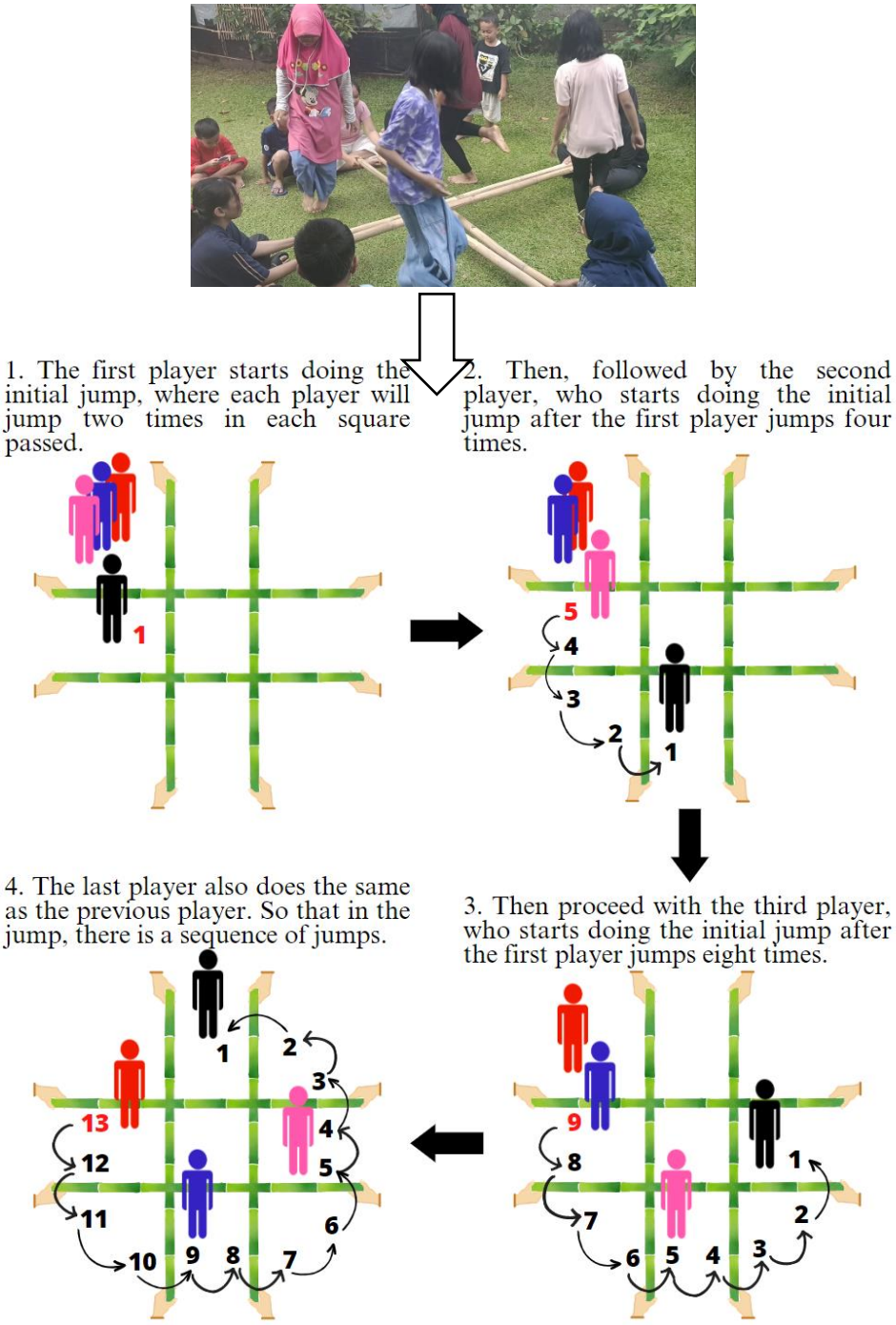

Figure 6. The sixth number pattern in the *Rangku Alu* traditional game

Figure 6 illustrates a sequence of jumps executed while leaping over the bamboo patches. This activity can also be perceived as a pattern contingent upon the position of each player initiating the jump within each plot. This pattern manifests as 1, 5, 9, and 13, where the interval between player one and the subsequent player is a difference of four counts. Consequently, the disparity delineates the jumper's position when executing the leap, calculated from the initial jumper's jump sequence. Number patterns can also be seen when only two jumpers are shown in Figure 7. It illustrates a noticeable discrepancy in the sequence of jumps between the first

and second players in the *Rangku Alu* game, leading to a distinct pattern of 1 and 9. This pattern emerges from the varying jump sequences observed between these two players, indicating differences in their approach to the game or strategic variations in how they navigate the bamboo squares.

Such a pattern can be analyzed to explore the diversity of gameplay styles and the flexibility inherent in traditional games like *Rangku Alu*. The discrepancy between the players' jump sequences can also provide insights into the range of possible outcomes within the game's structure, emphasizing the dynamic and adaptable nature of these traditional activities. By examining these variations, researchers can deepen their understanding of the game's complexity and its potential as a platform for exploring mathematical concepts and problem-solving strategies.

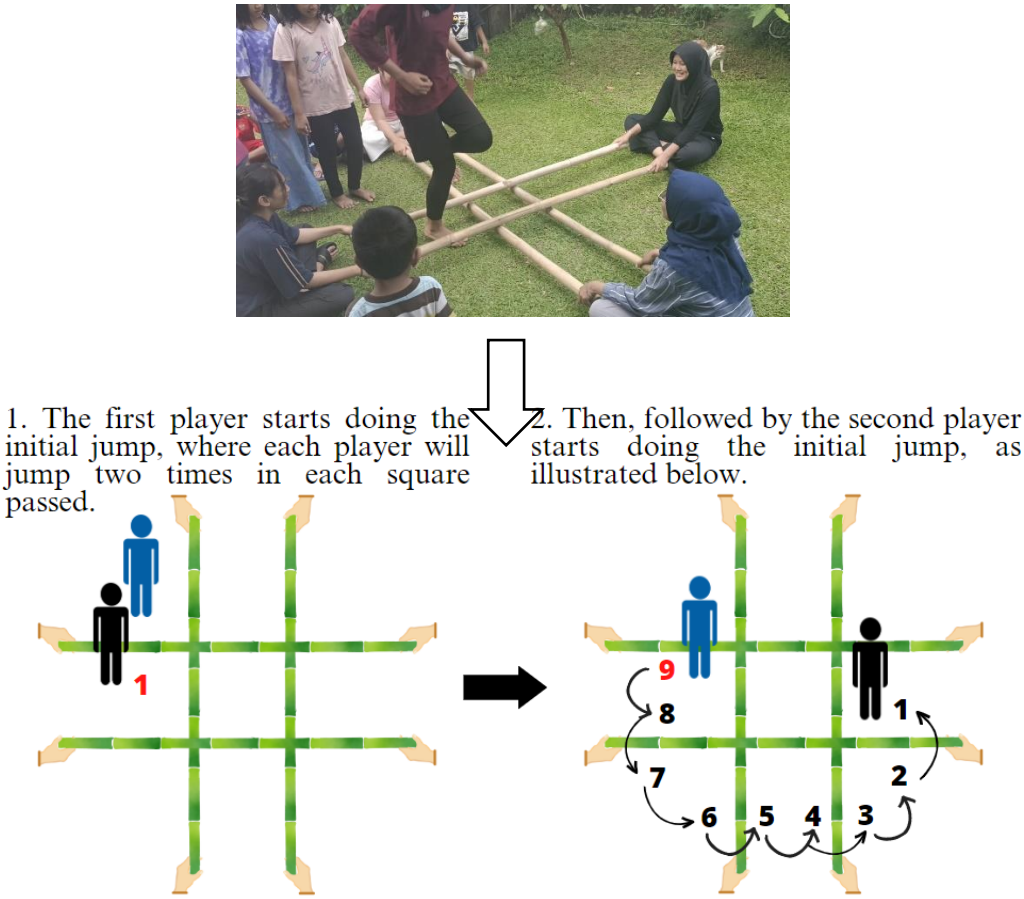

Figure 7. The seventh number pattern in the *Rangku Alu* traditional game

Discussion

The *Rangku Alu* game, known for promoting concentration, skill, agility, and movement precision, has proven to be an effective tool for enhancing mathematics education. By incorporating questions related to the game into teaching methods—such as calculating the

number of players at the game's start—educators can make learning mathematics more engaging, enjoyable, and exciting for students. This approach not only supports the development of mathematical skills but also allows students to deepen their understanding of Indonesian culture, with a particular focus on the heritage of East Nusa Tenggara. Integrating *Rangku Alu* into educational curricula plays a crucial role in preserving Indonesian culture, which aligns with informants' insights that emphasize the tendency of today's children to prefer virtual interactions over traditional, real-world experiences. This trend underscores the need to reintroduce traditional games to contemporary youth.

Furthermore, the fact that many children are unfamiliar with traditional Indonesian games highlights the importance of educating them about the history and cultural significance of these activities. By using the *Rangku Alu* traditional game as a teaching tool, educators can foster not only mathematical learning but also cultural appreciation and preservation. This approach helps bridge the gap between digital preferences and real-world experiences, meeting the evolving interests of today's youth while promoting a deeper connection with Indonesia's cultural heritage. Ultimately, the use of traditional games like *Rangku Alu* in educational settings serves as a dual-purpose strategy: it enhances academic outcomes in mathematics and contributes to the ongoing preservation of Indonesia's rich cultural traditions.

The ethnomathematical exploration of the *Rangku Alu* traditional game uncovers a significant relationship between the game and mathematical concepts, particularly in the realm of number patterns. As players interact with the rhythmic tapping of bamboo, synchronized with a musical beat or song, they create various sequences that embody mathematical principles. These sequences emerge from the coordinated actions of bamboo holders and jumpers, with patterns deriving from the timing, order, and frequency of jumps. This inherent mathematical structure in a cultural context underscores the potential of traditional games to serve as engaging and culturally relevant tools for teaching mathematical concepts.

The application of number patterns in the *Rangku Alu* game aligns with a growing body of research focusing on ethnomathematics within Indonesian culture. For instance, prior studies have examined how cultural artifacts contain mathematical insights, such as using Gringsing batik motifs to introduce geometric concepts (Permita et al., 2022), or analyzing the learning trajectories derived from Indonesian shadow puppets and Mahabharata stories (Risdiyanti & Prahmana, 2021). These studies reveal that Indonesian culture, with its rich tradition and storytelling, offers a fertile ground for exploring mathematics in contexts that resonate with learners' cultural backgrounds and experiences.

In addition to these examples, other research has shown how traditional games can serve as effective educational resources for teaching mathematical concepts. For instance, the study of the Barathayudha war stories and Uno Stacko provides insights into understanding number patterns (Risdiyanti & Prahmana, 2020b), while social arithmetic learning has been examined through the *Kubuk Manuk* games (Risdiyanti et al., 2019), and using the traditional game of *Congklak* in learning modulo (Khasanah et al., 2023). These explorations demonstrate the versatility of ethnomathematics, illustrating how traditional stories and games can illuminate mathematical ideas in a way that is both accessible and engaging to students. The adaptability

of these approaches reflects the need for innovative educational strategies that bridge the gap between culture and learning.

Therefore, the *Rangku Alu* traditional game emerges as a valuable resource for both mathematical education and cultural preservation. Its capacity to engage learners with rhythmic patterns and cultural stories provides an enriching experience that extends beyond conventional classroom settings. By incorporating the *Rangku Alu* game into educational curricula, teachers can create a learning environment that fosters mathematical understanding while promoting a deeper appreciation for Indonesia's cultural heritage. This approach aligns with the broader goals of ethnomathematics, which seeks to recognize and honor the diverse ways in which different cultures have contributed to mathematical knowledge, ultimately creating a more inclusive and meaningful educational experience.

Conclusion

The *Rangku Alu* traditional game, native to Flores Island in the Manggarai region of East Nusa Tenggara, originally emerged as a dance ritual to honor a successful harvest. The game holds deep philosophical meaning, representing an expression of gratitude to the divine for the season's agricultural bounty. The bamboo used in the game symbolizes the traditional rice pounders commonly employed by the Manggarai people. The gameplay involves participants divided into two groups: one group of four people holding bamboo poles and another group with at least one player tasked with jumping over the bamboo as it is rhythmically moved.

Players in the bamboo-holding group coordinate their movements, tapping the bamboo pieces together in a rhythmic pattern. The jumpers must time their movements carefully to avoid being struck by the bamboo. This synchronization and precision require both physical skill and concentration, which is why the game is not only entertaining but also an effective team-building exercise. Overall, the *Rangku Alu* game reflects a rich cultural heritage, emphasizing unity, cooperation, and shared tradition among the Manggarai people.

Research in ethnomathematics related to the *Rangku Alu* traditional game focuses on uncovering various numerical patterns intrinsic to the game's structure. These patterns emerge from the rhythmic beating of the bamboo poles, the sequence of jumps, and the arrangement of the jumpers. Within this study, seven distinct types of number patterns are identified, including odd number patterns, even number patterns, and arithmetic number patterns. This exploration demonstrates how traditional games can offer alternative frameworks for learning mathematical concepts, particularly in understanding the principles and applications of number patterns.

The *Rangku Alu* game, with its cultural and rhythmic elements, can serve as an innovative context for mathematics education. Integrating this traditional practice into classroom settings allows students to engage with mathematical concepts in a manner that is both meaningful and culturally relevant. By connecting with cultural heritage, students may find mathematics more approachable and relatable. This approach can foster a deeper appreciation for mathematics while celebrating cultural diversity and preserving traditional practices.

While the exploration of number patterns within the *Rangku Alu* traditional game offers valuable insights into ethnomathematics, there are limitations to consider. One limitation is the

potential difficulty in quantifying and formalizing the observed patterns, particularly within the context of a traditional, fluid game. Additionally, cultural nuances and variations in gameplay among different communities may impact the consistency and generalizability of findings. Furthermore, the focus on number patterns within the game may overlook other mathematical concepts and their cultural significance.

Further research in this area could address these limitations and expand our understanding of ethnomathematics in traditional games. Future studies could explore the cultural and historical context of the *Rangku Alu* game, investigating how mathematical principles are embedded within broader societal practices and beliefs. Additionally, research could examine the role of the game in social and cognitive development, considering how participation may enhance problem-solving skills and spatial reasoning. By adopting a more holistic approach to studying traditional games like *Rangku Alu*, researchers can uncover deeper insights into the intersection of mathematics, culture, and education.

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Conflicts of Interest

The authors declare no conflict of interest regarding the publication of this manuscript. In addition, the authors have completed the ethical issues, including plagiarism, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies.

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Author Contributions

Suci Pangestuti: Conceptualization, writing - original draft, editing, and visualization; **Rully Charitas Indra Prahmana:** Writing - review & editing, formal analysis, and methodology; **Frankie A. Fran:** Writing - review & editing, validation, and supervision.

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