AXIOM : Jurnal Pendidikan dan Matematika
(2024) Volume 13, No. 2, Page 193-206
https://doi.org/10.30821/axiom.v13i2.22087

Exploring ethnomathematics in tradition games: Hopscotch and marbles for generation Z

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Received: 15 October 2024 / Accepted: 19 December 2024 / Published Online: 31 December 2024

Abstract
In the digital era, information and communication technology (ICT) devices have replaced the function of traditional games such as hopscotch and marbles, leading to a decline in Generation Z's interest in these activities. Ethnomathematics serves a strategic role as a bridge between local culture and mathematical concepts, enhancing student engagement and supporting culture-based curricula. This study aims to explore the mathematical concepts embedded in traditional games, such as hopscotch and marbles, played by Generation Z. A qualitative approach employing ethnographic methods was utilized to investigate the relationship between these games and mathematical concepts. Data were collected through participant observation, semi-structured interviews, and documentation studies of Generation Z individuals who still engage in traditional games in North Sumatra, alongside document analysis related to curriculum and mathematics education. The study's findings on traditional games, such as hopscotch and marbles, provide insights based on participants' learning experiences and mathematical content encompassing geometry, measurement, probability, and mathematical operations. From an ethnomathematical perspective, traditional games introduce mathematics contextually and meaningfully. Ethnomathematics in traditional games has the potential to enhance mathematical understanding and contribute to the preservation of local culture among Generation Z.

Keywords: Ethnomathematics, Generation Z, Traditional games

How to Cite: Siregar, N.E.P., & Nuh, M. (2024). Exploring ethnomathematics in tradition games: Hopscotch and marbles for generation Z. *AXIOM : Jurnal Pendidikan dan Matematika*, *13*(2), 193-206. https://doi.org/10.30821/axiom.v13i2.22087

Introduction

Ethnomathematics is a learning approach that integrates local culture into mathematics, making the subject more relevant and contextual for students. Traditional games such as hopscotch and marbles, once popular in society, are now increasingly neglected due to the influence of digital technology. This is consistent with (Maulida, 2020) that Generation Z prefers digital games over traditional games, which are perceived as less engaging. However, traditional games like hopscotch and marbles contain educational and mathematical learning values, including concepts of geometry, measurement, and probability (Febriyanti et al., 2019; Wahid & Samta, 2022)

These local cultural values are marginalized if they are not preserved (Taskiyah & Widyastuti, 2021). This condition highlights the need for an approach that connects

mathematics learning with local culture. As Lidinillah et al. (2022) state, ethnomathematics serves as a link between mathematical thinking patterns and community culture. This approach is also relevant in facing the challenges of the digital era, as students require meaningful and culture-based learning (Putra & Mahmudah, 2021).

In addition to preserving culture, ethnomathematics also contributes to enhancing the quality of mathematics education and learning. Stacey (2011) demonstrated that students in Indonesia often struggle with solving contextual problems due to the formal nature of mathematics instruction. Traditional games, such as hopscotch and marbles, can facilitate the application of formal mathematics in everyday life (Risdiyanti & Prahmana, 2018). Moreover, research by Nurhayanti et al. (2021) highlighted that introducing culture through ethnomathematics can enhance students' abilities to apply mathematical concepts in various contexts. Wahyuni (2021) also noted that integrating local culture into mathematics learning helps students more easily grasp the concepts being taught. Thus, ethnomathematics not only preserves culture but also serves as a relevant mathematics learning solution for students in the digital era, particularly Generation Z (Luqnia et al., 2023).

On the other hand, digital technology presents new challenges for the preservation of traditional games. Generation Z teenagers apparently prefer digital games, which are considered more practical and interesting than traditional games (Maulida, 2020; Naafi' & Irawan, 2022). This shift has resulted in traditional games no longer being widely practiced, despite their educational benefits, such as training motor, cognitive, and social skills (Koa & Malessy, 2021). Wahid and Samta (2022) demonstrated that traditional games can be adapted into mathematics learning to attract students' interest while preserving local culture.

Additionally, research by Taskiyah and Widyastuti (2021) revealed that integrating traditional games into the curriculum and mathematics learning not only enriches teaching materials but also strengthens students' connections with their cultural environment. Thus, the perspective and philosophical values of ethnomathematics in traditional games become a strategic scientific foundation, contributing to the preservation of local culture and the improvement of mathematics learning quality (Firnanda & Sari, 2024; Nurhayanti et al., 2021).

In the context of mathematics learning, research by Putra and Mahmudah (2021) demonstrates that students taught using an ethnomathematics approach have a better understanding of the relevance of mathematics in their lives. Wahyuni (2021) further elaborates that ethnomathematics bridges formal mathematics with everyday life through local culture. Other studies have indicated that traditional games such as hopscotch, with its geometric patterns, and marbles, with its probability concepts, provide tangible contexts for mathematics learning (Aprilia et al., 2019). For instance, hopscotch can be used to introduce geometric concepts such as symmetry and rotation, while marbles can be utilized to teach probability and statistics (Febriyanti et al., 2019; Wahid & Samta, 2022). Efforts to incorporate traditional games, such as hopscotch and marbles, into mathematics learning serve not only to engage students but also to involve Generation Z in preserving local culture from an early age (Maulida, 2020; Naafi' & Irawan, 2022).

However, despite its significant potential, research on the integration of traditional games into mathematics learning through an ethnomathematics approach remains limited. Several studies, such as those by (Firnanda & Sari, 2024; Wahid & Samta, 2022), have demonstrated

that traditional games can serve as an effective medium for learning mathematics. Meanwhile, research by Risdiyanti and Prahmana (2018) has emphasized that incorporating local culture into mathematics education can help students understand the relevance of mathematics in everyday life. The process of exploring traditional games represents an effort to integrate ethnomathematics into the curriculum and learning. This approach addresses the challenges of teaching mathematics in the digital era while supporting the preservation of local culture (Lidinillah et al., 2022).

This study focuses on traditional games as a means to introduce mathematical concepts to Generation Z. The selection of hopscotch and marbles is based on their popularity in local culture and their potential to encompass mathematical concepts and principles. The contribution of this study is expected to support the development of a mathematics curriculum and learning framework based on local cultural values relevant to Generation Z (Sumarsono, 2022). Therefore, this study aims to explore traditional games such as hopscotch and marbles, which contain mathematical concepts, principles, and procedures. The potential of these two games can enrich the curriculum and mathematics learning, as well as preserve local culture. Efforts to integrate local culture into the curriculum and learning through an ethnomathematics approach are expected to address the challenges of digital-era mathematics learning based on local culture, and make it relevant to Generation Z (Aprilia et al., 2019; Naafi' & Irawan, 2022; Wahyuni, 2021).

Methods

This study employs a qualitative approach with an ethnographic design, aiming to explore the relationship between traditional games and mathematical concepts within the context of local culture (Moleong, 2017; Sugiyono, 2017). The research was conducted in Sei Rotan Village, Percut District, Sei Tuan, Deli Serdang Regency, North Sumatra, involving five teenagers born in 2010 and 2011 as participants. The study spanned six months, from May to November 2024. The selection of locations and subjects indicated interaction between participants and traditional games within the local community, as they remained interested in playing hopscotch and marbles in their daily lives (Hera & Elvandari, 2021).

The researcher's access to the participants began with the familiarity of being neighbors in the same environment, with some participants being close family members and others knowing each other from school. The communication process was open and voluntary between the researchers and participants, ensuring supportive conditions for observation and a conducive atmosphere for interviews, participant observation, semi-structured interviews, and documentation studies.

Observations were utilized to examine the mechanics of the hopscotch and marble games, and to identify the mathematical concepts, principles, and procedures contained within these games. Semi-structured interviews were conducted to explore students' perceptions of the relationship between mathematics and traditional games (Fauzi, 2022; Taskiyah & Widyastuti, 2021). Documentation included audio recordings, photos, videos, and field notes to provide additional evidence and strengthen the data (Moleong, 2017; Sugiyono, 2017).

Data analysis followed the Miles and Huberman model, which includes data reduction, data presentation, and drawing conclusions (Moleong, 2017; Sugiyono, 2017) The data were analyzed inductively to identify mathematical concepts, principles, and procedures in traditional games, such as geometric patterns in hopscotch and probability in marbles. Data validity was strengthened through triangulation of methods, time, and sources, as well as validation of results with research subjects (Creswell & W, 2017; Kurniati, 2016).

Results

Participant demographics

This study involved five participants, both male and female adolescents of junior high school age, from a play community in Sei Rotan Village, North Sumatra. Participants were selected based on their involvement in traditional games, such as hopscotch and marbles, both at home and at school. Each participant had varying demographic characteristics, reflecting a diverse representation of Generation Z, as presented in Table 1. The selection of these participants aimed to uncover game strategies and procedures with the potential to inform a culture-based mathematics curriculum and learning through an ethnomathematics approach.

Table 1. Demographics of Participants

No.	Subject	Age	Gender	Which school are you from
1.	S1	13	P	S1 Middle School
2.	S2	13	P	S2 Middle School
3.	S3	14	P	S3 Middle School
4.	S4	13	L	S4 Middle School
5.	S5	13	L	S5 Middle School

Based on Table 1, the first participant, S1, is a 13-year-old female student from S1 Middle School. S2, also 13 years old, is S1's classmate from the same school. S3 is a 14-year-old female student from S3 Middle School, providing a more senior dimension of experience among members of the gaming community. Meanwhile, S4, a 13-year-old male student from S4 Middle School, enriches the perspective with the inclusion of male participants in traditional games. Lastly, S5 is a 13-year-old student from S5, offering additional perspectives from a different educational institution. All participants are between 13 and 14 years old, which is a critical age for forming cultural preferences and engaging in traditional games. The diversity of their educational backgrounds provides unique insights into their understanding, application, and appreciation of the cultural values associated with these games.

Observation result data

The results of the observation indicate that the game of hopscotch begins with the creation of a grid pattern on the ground to serve as a playing field (see Figure 1). This pattern can take the form of trees, houses, people, or other variations. Generally, the shape of the engklek squares is consistent, but it is uniquely positioned only at the top. In preparing for the engklek game, players determine the order of turns using a method like hompimpa and select

a gacuk, which is a small stone to be thrown into the squares. During the game, players jump over the squares in numerical order without touching the lines while retrieving their gacuk, as illustrated in Figure 2. Preparation for the *engklek* game involves three stages: (a) creating *engklek* squares, (b) performing *hompimpa,* and (c) playing according to the determined turns.

The rules of hopscotch are stringent, prohibiting players from touching the lines or failing to retrieve the *gacuk*. Points are calculated based on the distance players cover in completing the squares, with additional points awarded for reaching star or bonus opportunities. This game involves the application of tactile mathematical concepts such as movement coordination, pattern calculation, and body balance maintenance. Students respond enthusiastically to this game as it combines enjoyable physical activity with social interaction among friends.

Figure 1. Variation Form of Engklek Square

(a) (b) (c)

Figure 2. Engklek Game Preparation

Based on the observation results, the marble game is played using a glass ball with a diameter of 16.30 mm. It is usually played on a flat ground surface within a defined area known as the game arena. The marble game arena is typically circular or square and serves as a place to collect marbles, as shown in Figure 3(a). These marbles are a collection of marbles that form the targets in the game arena, as illustrated in Figure 3(b). Additionally, the starting

line for players in the game arena is depicted in Figure 3(c). The function of the starting line is to serve as a boundary for aiming or shooting marbles in the game arena.

(a) (b) (c)

Figure 3. Marble Game Arena Shape

The marble game procedure consists of four main stages, as depicted in Figure 4. The first stage involves performing hompimpa to determine the players' turns and the order of play, as shown in Figure 4(a). In the second stage, players collect marbles in the agreed-upon quantity, and this collection of marbles is illustrated in Figure 4(b). The marbles are then positioned in a circular game arena.

In the third stage, according to the rules, players line up from right to left, indicating the order of play, as shown in Figure 4(c). The fourth stage involves players applying their strategy for aiming or shooting marbles. At this stage, the aiming strategy targets two objectives: the collection of marbles in the game arena and the marbles of other players. To win the marble game by hitting the target, players must consider the calculation of distance and their aiming strategy. This activity is illustrated in Figure 4(d).

(a) (b) (c) (d)

Figure 4. Marble Game Procedure

Interview result data

The interview process for all participants focused on three main topics: (a) game preparation, (b) game procedures, and (c) game rules. The interviews employed a semi-structured question guide with time triangulation. Table 2 presents a summary of the results of field notes collected during the interview period.

Table 2. Interview Results

No.	Question	Answer	
		Hopscotch Game	**Marble Game**
1	What do you know about how to prepare for the game of hopscotch and marbles?	Usually when playing engklek you draw the plot first, it's up to you which picture you want, ask your friends, look for a ceramic gacuk , then make *hompimpa* , then play in the order you play.	Play *hompimpa marbles* first, then collect the betting marbles (read: compete) and place them in the middle circle.
2	How to play hopscotch and marbles?	When playing hopscotch, we first throw the gacuk on the first square, then we jump around according to the hopscotch square, until we win and don't lose. If we lose, we take turns with the next friend in line.	We play marbles by shooting *marbles with* our fingers, then we aim them at the target.
3	What are the rules of the game hopscotch and marbles?	There are rules in the game of hopscotch, namely you have to *hompimpa* first, then jump according to the first square until you return to the first square without touching the line, and you are not allowed to step on squares that have *gacuk* on them .	The marbles must be *hompimpa* first, and *the marbles* must not enter or stop in the circle or marble arena, if they enter it means they lose.

Interview data from participants in the playing community revealed the main elements of the games of hopscotch and marbles. During the interview process, the researcher identified three focal points in the game of hopscotch: the form of preparation for the game, the game procedures, and the rules or strategies involved. Similarly, for the traditional game of marbles, the researcher highlighted three elements: the form of the arena and the playing process, the rules of the game, and the strategies to win.

According to participants' statements, the game of engklek can take various forms, such as people, houses, and trees. Participants also described the steps of playing engklek, starting with the preparation of drawing the engklek squares, performing hompimpa to determine the turn or order of play, and the actual game process. The strategy of the engklek game was also explained by the participants, noting that if one or several players obtain a star on a certain square, they gain control over that square. The game of engklek is played according to the agreement made at the beginning, with the objective being to obtain the most stars and thereby determine the end of the game.

According to the participants' submissions, marble games usually have a game arena in the form of a circle or square on an open field, where the collected marbles are placed. Additionally, participant S4 noted that there is a starting line in the game arena to designate the starting point for players aiming their marbles at the game arena.

The marble game also has specific rules, as stated by the participants. If the targeted marble is hit by the gacuk, it becomes the property of the player who aimed at it. The playing techniques used in everyday life vary according to gender. In marble games, men typically aim with the palm of their hand without touching the ground, while women usually touch or rest their hand on the ground to make aiming easier.

Interview data also reveals that traditional games of hopscotch and marbles incorporate various mathematical concepts, such as counting, geometry, probability, measurement, and arithmetic operations. These elements demonstrate that traditional games can serve as a contextual, engaging, and culturally relevant medium for learning mathematics.

Documentation data

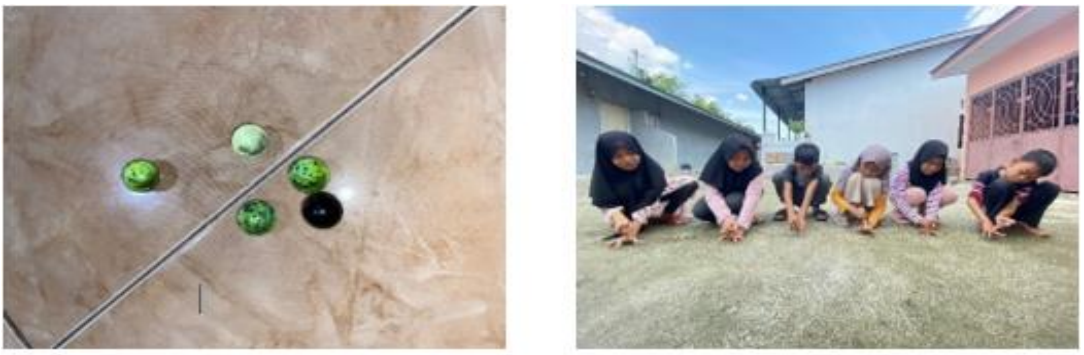
The results of the documentation in this study include visual artifacts obtained through observations of the participants' playing communities. These artifacts consist of images that reflect traditional game activities in both engklek and marbles games. This information serves as relevant documentation to demonstrate the ethnomathematical basis of both games.

In the engklek game, there are three elements that trace the game activities, as shown in Figure 5: (a) the engklek game procedure, (b) the gacuk, which is key to collecting points in the form of stars and is crucial for the strategy to win the game, and (c) the numbering of the engklek squares, which serves as the reference for progressing in the game ranking.

(a) (b) (c)

Figure 5. Documentation Results of Engklek Game

In the marble game, there are two elements: (a) the shape of the marbles, and (b) the position of the marble game sequence, which is arranged and agreed upon by the players. This is illustrated in Figure 6. Figure 6(a) shows the shape of the marbles, representing the surface area of the ball, while Figure 6(b) depicts the position of the game sequence, resembling a number line.



(a) (b)

Figure 6. Marble Game Documentation

Discussion

Generation Z's knowledge of engklek and marbles

Generation Z teenagers' knowledge of traditional games such as hopscotch and marbles in Sei Rotan Village remains quite good, although their involvement in these games has decreased compared to previous generations. Interviews with participants and observations by researchers indicate that they understand the basic procedures of the games, including the use of hompimpa to determine turns for playing hopscotch and marbles. The mathematical concept inherent in the hompimpa activity is probability. As illustrated in Table 3, players have samples of White (P) and Black (H) hand colors. Consequently, players determine the Black hand color (H) as the choice for the winner of the playing position order and as the opportunity to determine the playing sequence.

Table 3. Probability of Black Back Hand (H) in Englek and Marble Games

S1	S2	S3	S4	S5	Opportunity
H	H	H	H	H	Possibility-1
H	H	H	H	P	Possibility-2
H	H	H	P	P	Possibility-3
H	H	P	P	P	Possibility-4
H	P	P	P	P	Possibility-5
P	P	P	P	P	Possibility-6
P	P	P	P	H	Possibility-7
P	P	P	H	H	Possibility-8
P	P	H	H	H	Possibility-9
P	H	H	H	H	Possibility-10

Sample space {HHHHH, HHHHP, HHHPP, HHPPP, HPPPP, PPPPP, PPPPH, PPPHH, PPHHH, PHHHH}

n(S) = 10

n(A) = HPPPPP, PPPPPH = 2

P(A) = n(A) / n(S) = 2 / 10 = 0.2

Teenagers also recognize aspects of local culture, such as variations in the shape of the hopscotch tiles (e.g., houses, people, mountains) which are created creatively based on mutual agreement. According to the interview results, participant S1 explained, "We start the game with hompimpa to determine the turn." S1 added, "We also choose more interesting tile shapes, such as the shape of a person or a house." Additionally, the use of gacuk made of stone or flat ceramics is common, as illustrated in Figure 7.

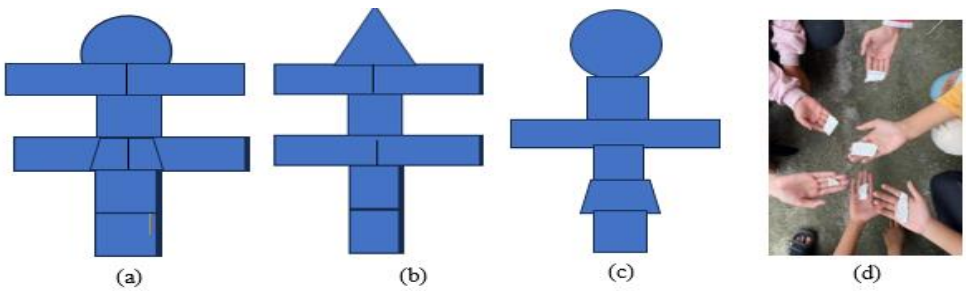


Figure 7. Petak and Gacuk Engklek

In the game of marbles, several mathematical concepts are applied. These include calculating the number of marbles through addition and multiplication. For example, if each player collects 5 marbles and there are 6 players:

Addition: $5 + 5 + 5 + 5 + 5 + 5 = 30$

Multiplication: $5 \times 6 = 30$

According to S4's explanation, "The game is played in alternating rows after hompimpa until it's their turn." The mathematical concept in the marble game activity includes arranging the players' positions like a number line according to the order of play, as illustrated in Figure 8.

Figure 8. Player Positions on the *Starting Line*

Traditional games such as hopscotch offer geometry and congruence-based learning that can be applied in real life. In addition, (Wahid & Samta, 2022) stated that games such as marbles involve the concepts of probability and number lines, which are relevant in mathematics education. However, adolescents' interest in traditional games has been increasingly displaced by the influence of digital games, which are considered more engaging and easily accessible (Naafi' & Irawan, 2022). Despite this, traditional games still provide significant educational benefits. (Risdiyanti & Prahmana, 2018) asserted that traditional games not only connect students with local culture but also introduce mathematics in real contexts.

Efforts to integrate traditional games into ethnomathematics-based learning, such as hopscotch and marbles, can serve as a relevant medium for teaching mathematics contextually while preserving local culture amidst the challenges of the digital era.

Cultural integration in mathematics learning: An ethnomathematics perspective

Cultural integration in mathematics learning through the perspective of ethnomathematics offers a more contextual and relevant approach to students' lives, particularly in introducing mathematical concepts derived from local cultures. In the context of traditional games such as hopscotch and marbles, ethnomathematics connects local culture with mathematics learning, enabling students to understand and apply mathematical concepts in their daily lives. This aligns with the findings of (Risdiyanti & Prahmana, 2018), who state that ethnomathematics provides opportunities for students to learn mathematics through cultural experiences familiar to them.

Ethnomathematics in mathematics learning also has a positive impact on students' interest and motivation. As (Wahid & Samta, 2022) explain, this approach can enhance students' engagement with mathematics, as they learn not only from textbooks but also from direct experiences within their culture. This makes mathematical concepts easier to comprehend and accept, as students can relate theories to real experiences in their daily lives..

Mathematical aspects inherent in traditional games of engklek and marbles

Both hopscotch and marbles games reflect the direct application of mathematical concepts in everyday life. Through these traditional games, students can observe how mathematics is utilized in their social and cultural contexts, thereby making learning more relevant and meaningful. In his research, (Aprilia et al., 2019) explained that the use of traditional games such as hopscotch and marbles in mathematics education motivates students and simplifies the understanding of abstract concepts. This is understandable because students are directly connected to experiences and cultures they are familiar with.

Overall, these traditional games offer a rich context for teaching various mathematical concepts while preserving local culture. The integration of ethnomathematics through games like hopscotch and marbles enables students to comprehend mathematics not merely as an isolated discipline but as an integral part of their daily lives, fostering more applied and enjoyable learning.

Characteristics of activities that demonstrate " ethnomathematics " in traditional games of engklek and marbles for generation Z

Activities involving traditional games of hopscotch and marbles demonstrate a robust application of ethnomathematics, merging local culture with contextual mathematics learning. Through these games, Generation Z teenagers not only learn mathematical concepts such as geometry, probability, and arithmetic, but also develop social skills and a deeper understanding of culture. Integrating these traditional games into the mathematics curriculum allows students to learn mathematics in a more enjoyable, relevant, and meaningful way, while preserving their cultural heritage (Yuliana & Zahroh, 2024)

The relationship between ethnomathematics and generation Z youth knowledge in traditional games of engklek and marbles

Traditional games such as hopscotch and marbles embody cultural values and mathematical aspects that have significant potential for use in ethnomathematics-based learning. Ethnomathematics, which connects mathematical concepts with local culture, provides a relevant context for students, particularly Generation Z, to understand mathematics through familiar cultural experiences. Based on reports and research data, the relationship between ethnomathematics and Generation Z's knowledge can be explained through aspects of culture, mathematics, and contextual learning.

The relationship between ethnomathematics and Generation Z's knowledge of traditional games like hopscotch and marbles lies in the integration of culture and mathematical concepts in game activities. These games offer students the opportunity to understand mathematics contextually, strengthen cultural identity, and enhance their learning motivation.

(Risdiyanti & Prahmana, 2018) demonstrated in their research that ethnomathematics can increase student engagement in mathematics learning by connecting abstract concepts with everyday cultural activities, such as traditional games.

The contribution of ethnomathematics in hopscotch and marble games to the understanding of mathematics for Generation Z

Ethnomathematics, as a culture-based learning approach, makes a significant contribution to helping Generation Z understand mathematics in a more contextual and engaging manner. Traditional games such as hopscotch and marbles serve as relevant media because they encompass various aspects of mathematics that can be applied in everyday life, aligning with students' local cultural experiences.

1. Contribution to the Understanding of Geometry Concepts
   The hopscotch game involves geometric shapes such as triangles, squares, and circles, which are used to create game tiles. Through this activity, Generation Z can learn about plane shapes, geometric properties, and congruence. (Wahid & Samta, 2022) stated in their research that the use of cultural aspects, such as the shape of hopscotch tiles, enhances students' practical and visual understanding of geometry. A similar observation was made in the game of marbles, where the circular arena helps students grasp concepts of size, distance, and angle measurement.
2. Integration of Probability and Arithmetic Operations
   In the game of hopscotch, activities such as hompimpa to determine turns introduce students to basic probability concepts. Meanwhile, the marble game involves arithmetic operations such as addition and multiplication to calculate the number of marbles in play. These activities provide practical applications of abstract mathematical concepts in real-life contexts, enhancing student engagement. (Elpina & Haris, 2023) explained in their study that traditional games such as hopscotch and marbles integrate mathematical concepts within the framework of local culture. Hopscotch teaches geometry through the shape of the game tiles and probability through the activity of hompimpa to determine turns. Conversely, the marble game involves mathematical operations such as addition and multiplication to calculate the marbles collected for play.

Conclusion

The results of the research and discussion on the exploration of ethnomathematics in traditional games for Generation Z conclude that traditional games such as hopscotch and marbles encompass highly relevant ethnomathematical values, incorporating various fundamental mathematical concepts that can serve as contextual learning media.

In hopscotch, students are introduced to geometric concepts through shapes like rectangles and triangles, and probability concepts via the hompimpa game to determine turns. Conversely, the marble game helps students understand geometric and measurement concepts through circles and number lines, and introduces basic mathematical operations, such as addition and multiplication, when counting the number of marbles.

The ethnomathematics approach in these two games provides insights into how to apply different mathematical concepts within the context of local culture, illustrating the relevance

of mathematics in everyday life. It serves as an effective link between mathematics education and local culture, offering an innovative solution that combines education with cultural preservation.

Declarations

Author Contribution : NEPS: Conceptualization, Writing - Original Draft, Editing and Visualization.
MN: Writing - Review & Editing, Formal analysis, and Methodology.
Conflict of Interest : The authors declare no conflict of interest.
Additional Information : Additional information is available for this paper.

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