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Combining the Concept of Plane Figures in the Game of Engklek through a Motion-Based Ethnomathematics Approach

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Abstract: Learning about flat shapes in elementary school is often conveyed thru images, definitions, and formulas that are not yet fully connected to the real experiences of the students. The game of hopscotch offers a cultural context as well as a concrete learning space because its playing pattern is composed of various geometric shapes and is played thru physical activity. This article aims to explain how the concept of flat shapes can be integrated with the game of hopscotch thru ethnomathematics, game-based learning, and movement-based learning approaches. The article is composed using a conceptual review of selected studies with DOIs that are available online. The synthesis results show that the hopscotch squares can be used to introduce squares, rectangles, triangles, semicircles, symmetry, congruence, perimeter, area, and composite shapes. Activities such as throwing the gaco, jumping, measuring squares, comparing shapes, and explaining game strategies allow students to connect visual representations, body movements, language, and mathematical symbols. This integration not only concretizes geometric concepts but also strengthens mathematical communication, collaboration, sportsmanship, and appreciation for local culture. Thus, the game of engklek can be developed into a contextual, active, and meaningful flat geometry learning environment, both in the form of direct play and interactive digital media.

Keywords: Flat Shapes, Hopscotch, Ethnomathematics, Geometry, Movement-Based Learning

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1. Introduction

Flat shapes are one of the basic materials in mathematics education that serve as the foundation for understanding geometry at the next level. Thru this material, students learn about shape, size, position, relationships between sides, angles, perimeter, area, symmetry, and spatial order. However, the learning of flat shapes often stops at the activity of memorizing the names of shapes and using formulas. As a result, students may be able to recite the area formula but do not yet understand how the formula relates to space, size, and objects encountered in everyday life.

The ethnomathematics approach offers a way to connect school mathematics concepts with cultural activities of the community. In this perspective, mathematics is not viewed merely as a collection of abstract knowledge, but also as a way for humans to measure, count, compare, design, categorize, and solve problems within a specific cultural context. D'Ambrosio places mathematical ability as part of human competence in understanding and interpreting reality [1], while Rosa and Orey emphasize the importance of connecting cultural knowledge with formal mathematics learning practices [2].

One of the cultural practices that has potential for use in mathematics education is the game of hopscotch. Febriyanti et al. identified squares, rectangles, and semicircles in the arrangement of hopscotch squares [3]. Other research shows that mathematical elements are also present in the shapes of the gaco, the sequence of squares, symmetry, congruence, numbers, logic, and the rules of the game. Thus, hopscotch can be understood as a geometric representation that is close to children's experiences, not just a game to pass the time [3], [4].

The use of engklek as a learning medium is also supported by development research. Utami et al. produced the Engklek Geometry media for quadrilateral material and reported that the developed media met valid criteria and could be used in learning [5]. Sarafiah and Khatimah also developed ethnomathematics-based hopscotch media for flat shape material in elementary schools and obtained positive results in validation [6], student responses, and learning completeness. The findings indicate that the structure of the engklek game can be pedagogically engineered without losing its cultural character and play elements.

2. Materials and Methods

This article uses a conceptual study approach based on selected literature. Literature was selected based on its relevance to four main themes, namely ethnomathematics, hopscotch games, flat geometry learning, and motion-based mathematics learning. Only articles with a DOI and available online are used as citation sources.

The analysis was conducted by identifying the geometric concepts found in the patterns and activities of the engklek game, then linking them to the theories of ethnomathematics, game-based learning, mathematical communication, and embodied learning. The results of the analysis were subsequently used to formulate the design of integrating the engklek game into flat shape learning.

3. Results and Discussion

Engklek as an Ethnomathematics Space

Engklek can be referred to as an ethnomathematics space because it contains a blend of cultural objects, physical activities, social rules, and mathematical concepts. Players must recognize the boundaries of the squares, estimate the direction of the throw, determine body position, maintain balance, count the sequence, and understand the relationships between the squares. All of these activities require spatial reasoning, even tho players do not always recognize them as mathematical activities.

Figure 1. Engklek as an Ethnomathematics space.

In Figure 1, the engklek pattern can be seen, which is usually formed from a combination of single squares and paired squares. In some variations, the end of the game is shaped like a semicircle, circle, or a field resembling a mountain. These shape variations provide concrete objects to identify squares, rectangles, circles, semicircles, and composite shapes. Meanwhile, the broken tiles or stones used as gaco can be in the shape of triangles, trapezoids, rectangles, or irregular shapes. Therefore, learning resources are not only found on the game board but also in the tools, rules, and movements of the players [3], [7].

That approach brings together informal knowledge with formal knowledge. Children initially recognize a square as a place to stand or jump. The teacher then helps transform that experience into mathematical concepts by introducing terms such as sides, vertices, length, width, perimeter, area, congruence, and symmetry. This process does not erase the cultural meaning of the game, but rather expands it into a source of knowledge formation.

Integration of Flat Shape Concepts

Introduction and classification of shapes

In Figure 1, the first stage of the hopscotch game can be seen. Students can be directed to activities of observing and classifying shapes. Students are asked to name the flat shapes found in the hopscotch pattern and explain the reasons for their classification. For example, a square can be categorized as a square if it has four equal-length sides and four right angles. A rectangle, on the other hand, can be categorized as a rectangle if its length and width are different.

Teachers need to avoid teaching that only requires students to name the shapes. They need to be given the opportunity to compare examples and non-examples. A square-like square can be measured to ensure the length of its sides, while an irregular-shaped figure can be discussed based on its most approximate characteristics. This activity helps students understand that geometric classification is based on properties, not just visual appearance.

Sides, vertices, and line relationships

In Figure 1, the boundary lines of the hopscotch squares can be seen, which can be used to introduce sides, vertices, parallel lines, intersecting lines, and perpendicular lines. Students can trace the lines using their fingers or walk along the boundaries of the squares while mentioning the changes in direction. Body movements provide a different experience from observing pictures in a book. When students spin at a corner or walk along the edges, geometric concepts are learned through the coordination of sight, language, and action. Studies on body-based mathematics learning show that movement and gestures can help learners build and communicate mathematical understanding. Movement activities can also serve as a foundation for developing an understanding of angles and spatial relationships [8], [9].

Perimeter and area

The concept of perimeter can be introduced by asking students to measure the entire outer boundary of a square using a ruler, tape measure, string, or non-standard units, as shown in Figure 1. Students then add up the lengths of each side and compare the result with the perimeter formula. The concept of area can be learned through square units. A hopscotch grid can be made on a tiled floor or overlaid with small grids so that students can count the number of square units covering a surface. After understanding the process, students are directed to find the relationship between the number of rows, the number of columns, length, width, and the area formula.

This approach allows the formula to be obtained through the process of observation and generalization. The formula is not provided as a ready-made rule, but rather constructed from activities of counting units and comparing sizes. The Geometric Engklek media developed by Utami et al. shows that this game can be systematically adapted to study quadrilateral material [5].

Congruence and similarity

In Figure 1, squares with the same shape and size can be seen, which can be used to explain congruence. Students can measure two squares, trace them on transparent paper, and then stack the two tracings. If both overlap perfectly, the squares are congruent.

The concept of similarity can be introduced by creating two hopscotch patterns of different sizes, but with the same side ratios. Students compare the small hopscotch pattern on the worksheet with the large hopscotch pattern in the schoolyard. In this way, comparison and scale are learned through familiar objects.

The potential of games similar to hopscotch for learning congruence is also demonstrated in the research by Payot et al. [10]. The Jump into Hopscotch approach resulted in differences in triangle congruence abilities between the group that received game-based learning and the non-game learning group. Although applied to middle school students, the principle shows that the structure of the hopscotch game can be adapted to facilitate more complex geometric reasoning.

Symmetry and reflection

In Figure 1, the arrangement of paired squares in hopscotch can be used to introduce fold symmetry. The teacher can draw a central line on the game pattern, then ask the students to identify the reflecting parts. Students can also design symmetrical and asymmetrical hopscotch patterns, then explain the differences.

Reflection can be simulated through body positions. A student stands on the left square, while their friend takes the corresponding position on the right. Both then move simultaneously as mirror images. Activities of this kind are relevant to the concept of embodied abstraction, which is the process of constructing abstract ideas through actions, observations, verbalization, and reflection on the structures that emerge in the activity [11].

Composite shape

The hopscotch pattern as a whole can be treated as a composite shape, as shown in Figure 1. Students can calculate the total area of the pattern by summing the area of each square. If the top part is shaped like a semicircle, its area can be calculated separately and then combined with the area of the square or rectangle.

Teachers can also provide open-ended challenges, such as asking students to create hopscotch patterns with a specific area, a certain number of squares, or a predetermined maximum perimeter. The problem not only tests the use of formulas but also demands planning, decision-making, and evaluation of the design.

Table 1. Mapping Game Components and Geometry Concepts.

Game Component	Two-Dimensional Shape Concept	Example of Learning Activity
Single square	Square and rectangle	Identifying sides, vertices, length, and width
Paired squares	Congruence and symmetry	Comparing sizes and determining the axis of symmetry
Mountain-shaped section	Circle or semicircle	Determining the diameter, radius, circumference, and area
Boundary lines	Parallel, perpendicular, and intersecting lines	Tracing lines and identifying relationships between lines
Throwing piece	Triangle, trapezoid, quadrilateral, or irregular shape	Classifying shapes and estimating area
Entire hopscotch pattern	Composite shapes	Calculating the total area and perimeter

Player movements	Position, direction, angle, translation, and reflection	Practicing movement and changes in direction

The mapping is flexible. Teachers can adjust the pattern, level of difficulty, and questions based on the age and learning achievements of the students. Research on engklek shows that this game can be developed for flat shape material, mathematical communication, and concept understanding while maintaining its cultural elements and play activities [12], [6].

Design of Learning Implementation

Learning can begin with cultural exploration. The teacher invites the students to share their experiences playing engklek, the name of the game used in their region, the variations in patterns, and the rules they know. This stage is important so that culture is not only used as decoration but understood as part of the students' social experience.

The next stage is pattern construction. Students work in groups to draw hopscotch squares using chalk, string, or adhesive tape. They must determine the shape, side lengths, number of squares, and their arrangement. The drawing activity allows students to directly use their skills in measuring, drawing lines, forming right angles, and maintaining size consistency.

At the game stage, each square can be linked to a question card. When the gaco lands on a certain square, the player must solve a question corresponding to the shape of that square. The questions can involve identifying properties, calculating perimeter, calculating area, determining symmetry, or comparing two shapes. A similar model has been described in the development of Engklek Gen 4.0, where the gaco and game squares are used to determine the math problems that need to be solved by the students [7].

After the game, the teacher needs to carry out the formalization process. Students present the measurement results, calculation strategies, errors found, and the mathematical reasoning behind their answers. The reflection stage is necessary so that the activity does not stop as a physical game. Through discussion, experiences of jumping, measuring, and observing are transformed into terms, representations, and formal mathematical principles.

Assessment can combine activity observation, pattern design, products, explanation skills, and written tests. The aspects being assessed are not only the accuracy of the answers but also the ability to connect shapes with their properties, use measuring tools, convey reasoning, and collaborate. The development of hopscotch games for mathematical communication shows that these activities can be designed to encourage students to express mathematical ideas both orally and in writing [12].

Game-Based and Movement Learning

The pedagogical value of hopscotch lies not only in the shape of its squares but also in the activity of playing. Players face goals, challenges, rules, turns, feedback, and the consequences of every decision. These elements are important characteristics of game-based learning.

The meta-analysis by Tokac et al. shows that game-based mathematics learning is generally associated with higher learning outcomes compared to traditional classroom learning [13], although the strength of the results is influenced by the design, type of game, and context of application. Therefore, the game of engklek needs to be designed with clear mathematical objectives, not just used as a diversion.

Engklek also has the advantage of being a movement-based learning activity. Children do not just see geometric representations, but stand within them, jump over their boundaries, change direction, estimate distances, and maintain body positions. That interaction allows the concept of space to be understood thru the relationship between perception and action. Studies on embodied mathematics learning emphasize that the body, gestures, tools, and environment can play a role in the formation of mathematical understanding [8], [11].

Development Toward E-Engklek

The game of engklek can be developed in digital or virtual reality form, but digitization should not eliminate its main character as a spatial and movement-based activity. The digital version can display changing patterns, provide automatic feedback, record scores, or present questions according to the selected square. However, users still need to be guided to perform movements, estimate positions, and interact with geometric objects.

Annisa et al. showed that the game of hopscotch can be adapted for the digital generation as a medium for learning mathematics as well as a means of cultural preservation [7]. This adaptation aligns with the idea that technology does not have to replace traditional games, but can expand their forms, access, and usage variations.

In the context of E-Engklek VR, each square can be designed as a geometric task space. Students can choose squares, manipulate side lengths, create symmetrical patterns, combine several shapes, or observe area changes directly. Nevertheless, the digital version still requires expert validation, user testing, usability measurement, and learning outcome evaluation to not only be visually appealing but also genuinely support the development of mathematical understanding [14], [15].

Pedagogical Implications

The integration of hopscotch and flat shapes provides several important implications. First, local culture can be positioned as a source of knowledge, not just as supplementary material. Second, the concept of geometry can be learned through concrete experiences before being formalized into symbols and formulas. Third, physical activities can help students connect physical space with mathematical representations. Fourth, the rules and interactions in the game create opportunities to practice communication, cooperation, honesty, and sportsmanship.

However, teachers must ensure the safety of the play area, the accuracy of the grid size, the appropriateness of the questions to the developmental level of the students, and the involvement of all group members. Teachers also need to avoid overly dominant competition because the main goal of the game is to build understanding. Learners with mobility limitations can be involved through board versions, miniatures, cards, or digital games to ensure inclusive learning.

4. Conclusion

The game of hopscotch provides a rich environment for learning about flat shapes because it combines geometric shapes, body movements, rules, social interactions, and local culture. The game squares can be used to introduce squares, rectangles, circles, semicircles, congruence, symmetry, perimeter, area, and composite shapes. Meanwhile, activities such as throwing, jumping, measuring, comparing, and explaining strategies allow students to build knowledge thru visual, kinesthetic, verbal, and symbolic experiences.

The integration of flat shape concepts with hopscotch needs to be carried out thru stages of cultural exploration, pattern construction, problem-based games, mathematical discussions, concept formalization, and reflection. With a directed design, hopscotch not only functions as a traditional game but also as an ethnomathematics medium that concretizes geometry, facilitates movement-based learning, and strengthens the connection between school mathematics and students' lives.

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