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Effectiveness of Ethnomathematics Learning with Taekwondo Basic Techniques in Understanding the Concept of Geometry for Junior High School Students

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ABSTRACT

The understanding of geometry concepts among junior high school students remains relatively low due to the abstract and teacher-centered nature of mathematics learning, which emphasizes formula memorization rather than meaningful conceptual understanding, making it difficult for students to connect geometry concepts with real-life contexts; therefore, an innovative and contextual learning approach, such as ethnomathematics-based learning, is needed. This study presents a novel approach by integrating ethnomathematics with basic taekwondo techniques through a systematic mapping of geometric concepts into structured taekwondo movement patterns, where kicking and stance positions represent angle types and measures, body turns illustrate rotational transformations, balanced stances demonstrate symmetry, and sequential movement patterns model basic geometric transformations. This research was conducted to evaluate the impact of integrating ethnomathematics instruction with fundamental taekwondo techniques on the understanding of geometric concepts among seventh graders at SMP Negeri 7 Pamekasan. The study utilized a quantitative approach with an experimental methodology featuring 40 students, who were split into two groups: an experimental class (VIIA) and a control class (VIIB), with each consisting of 20 students. Data collection involved pretests and posttests through written assessments and a validated questionnaire for student responses. The analysis of the data was executed using descriptive statistics, the N-Gain test, a homogeneity test, and a t-test. Findings revealed that the implementation of ethnomathematics education grounded in basic taekwondo techniques was significantly more effective in enhancing students' comprehension of geometric concepts compared to traditional teaching methods.

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Introduction

Mathematics is defined as a fundamental subject that is often considered difficult by students, especially in geometry learning which has a high level of abstraction and requires good spatial skills. The findings of interviews with mathematics educators at SMP Negeri 7 Pamekasan revealed that students still face obstacles in understanding geometry concepts. This condition is caused by a learning approach that tends to emphasize memorizing formulas without trying to connect the material with everyday experience. This makes student interest and involvement low (Mulyati & Evendi, 2020). A number of studies also revealed that the mastery of mathematics concepts for junior high school students in Indonesia is not optimal (Anjarwati et al, 2020). Emphasizing that low understanding of concepts is one of the main obstacles, Rosita (2021) added that this weakness has implications for learning outcomes that are not optimal. In learning geometry, students need a thorough understanding of concepts in order to be able to apply their geometry skills, such as visualizing shapes, identifying different types of flat and spatial shapes, providing picture descriptions, sketching buildings, recognizing similarities and differences between geometric shapes, as well as labeling certain points (Rizqi, 2023). In fact, many students still have difficulty understanding geometry and that becomes a real challenge.

The low level of students' understanding of geometry material is also due to the limited application of contextual approaches in the learning stage. Teachers still tend to apply methods that prioritize memorizing formulas without connecting them to the students' daily lives. This approach results in several negative impacts, including the tendency of students to focus on memory activities rather than understanding concepts in depth, difficulties in applying the concepts that have been learned to real-life situations, and a decrease in interest in learning which is marked by the rapid increase in students experiencing boredom due to limited active participation in the learning process. This condition aligns with the research findings of Anjarwati et al. (2020) and Rosita (2021), which stated that abstract and teacher-centered geometry learning results in low conceptual understanding in students. Other research conducted by Pratiwi & Pujiastuti (2020) and Safitri & Sulistyorini (2023) shows that cultural context-based learning through an ethnomathematics approach can increase student engagement and understanding because it connects mathematical concepts with real experiences. In addition, Mulyasari et al. (2021) and Naitili & Nitte (2023) demonstrated that the application of ethnomathematics through cultural activities such as traditional games has a positive influence on students' understanding of geometric concepts. Most of the research is still limited to the elementary school level and has not integrated much physical activity or martial arts as a context of geometry learning at the junior high school level, so innovative solutions are needed to provide more interesting, meaningful, and relevant geometry learning for junior high school students.

The solution that can be applied is ethnomathematics, which is mathematics learning that is associated with cultural elements so that the learning process becomes more meaningful (Safitri & Sulistyorini, 2023). One of the cultures that is easily accepted to integrate is the martial art of Taekwondo. Basic taekwondo movements contain many movement patterns that represent geometric shapes, such as lines, angles, and triangles. Therefore, taekwondo can be used as a contextual learning tool to enhance students' understanding of geometric concepts. Thus, culture-based learning as a form of innovation in mathematics learning can reduce the perception that mathematics is considered rigid (Pratiwi & Pujiastuti, 2020). Ethnomathematics is a bridge that can connect between culture and mathematics (Safitri & Sulistyorini, 2023). One of the most popular fields of mathematics is geometry, which is associated with various

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cultural contexts of people in different regions of Indonesia (Yunita & Suharni, 2023). Geometry is also very beneficial in life, so it is important to learn more (Suhartini & Martyanti, 2017). The application of ethnomathematics in geometry learning provides an opportunity for students to understand the relationship between mathematics and culture, so that the learning experience becomes more relevant and interesting. Learning geometry can incorporate cultural elements such as martial arts. Martial arts contain various movement patterns and geometric shapes. Therefore, martial arts is one of the media that has the potential to introduce geometric concepts in a more applicable and in-depth way.

Several previous studies have proven that ethnomathematics is effective in improving understanding of concepts. Naitili & Nitte (2023) found that the use of traditional games can strengthen the ability of elementary students to understand geometric concepts. Similarly Mulyasari et al. (2021), it shows that the engklek game has proven successful in improving the understanding of geometry concepts among students. However, most ethnomathematical research still focuses on the context of traditional games and is predominantly applied at the elementary school level, so its application at the junior high school level is still quite rare. The selection of basic techniques of Taekwondo as a context of geometry learning is based on the characteristics of its movements which are rich in representations of geometric concepts, such as parallel lines, intersecting lines, angles, and triangular flat shapes that appear in stances, kicks, and parrying. In addition, Taekwondo is a physical activity that is familiar to students and is able to involve visual, kinesthetic, and contextual aspects at the same time, so that it can minimize the abstract nature of geometry and increase students' active participation in the learning process. The novelty of this research lies in the systematic integration of basic Taekwondo techniques as an ethnomathematical context in geometry learning at the junior high school level, as well as the measurement of its effectiveness quantitatively through N-Gain analysis and statistical testing. Therefore, this research not only expands the scope of ethnomathematics studies at the junior high school level, but also presents practical contributions in the form of innovative alternatives in contextual learning that are meaningful to improve the understanding of geometry concepts for students at SMP Negeri 7 Pamekasan.

Method

Research Design

In this study, a quantitative research method was applied with the aim of obtaining data in the form of numbers and statistically analyzed to determine the effect of the treatment given. This approach was chosen because it is suitable to measure the effectiveness of ethnomathematics learning with basic taekwondo techniques in understanding students' geometric concepts objectively and measurably. This study used an experimental research method with a pseudo-design. The design involved two research groups, namely an experimental group that received ethnomathematics instruction through basic taekwondo techniques and a control group that received conventional teaching, making it possible to compare the differences in learning outcomes between the two groups.

Population and Sample

The population studied consisted of all grade VII students at SMP Negeri 7 Pamekasan, with sampling reaching 40 grade VII students taken through a special sample selection technique, then divided into two classes. Each group consisted of 20 students, of which class VIIA served as the experimental group and class VIIB as the control group. The determination

of the sample size of 40 students was based on the limited population found in two parallel classes in grade VII, the similarity of the students' academic characteristics, and the consideration of the effectiveness of the quasi-experimental design with a non-equivalent control group approach which requires a balance of the number of subjects between the experimental and control groups to ensure more objective and valid comparison results. In addition, the number of samples is considered sufficient to meet the needs of statistical analysis in measuring differences in learning outcomes and increasing students' understanding of geometry concepts quantitatively.

Instruments

The research instrument consisted of a written test and a questionnaire. Written assessments, which include pretest and posttest, are used as a means to assess students' understanding of geometry concepts before and after treatment. Meanwhile, a student response questionnaire that collected student responses was used to assess students' reactions to the application of ethnomathematics learning based on basic taekwondo techniques. All of these instruments have gone through a validation process.

Table 1. Examples of Preetest and Posttest Questions

No	Concept Understanding Indicators	Examples of Pretest Questions	Examples of Posttest Questions
1.	Identify and explain geometry concepts	It is known that the triangle ABC with ∠A = 40° and ∠B = 60° is known. Specify the magnitude ∠C and determine the type of triangle ABC based on the magnitude of its angle.	Based on the basic movements of taekwondo techniques that form angles and lines, determine the size of the angles formed and classify the types of triangles based on those angles.
2.	Applying geometry concepts in problem solving	It is known to be a triangle with angles of 30°, 60°, and 90°. Draw the triangle and determine the type of triangle along with a mathematical reason.	The movements of the basic technique of taekwondo form a right triangle. Determine the size of the corner or the length of the requested side and describe the completion steps.

Table 2. Expert Validator Result Data

No	Instruments	Average Rating		Average Total of Both Experts	Validity Criteria	Interpretasi
		Member 1	Member 2			
1.	Pretest	67,7	94,7	74,4	Valid	Suitable for use with minor revisions
2.	Posttest	71,8	93,7	82,8	Highly Valid	Very suitable for use without revision
3.	Student Response Questionnaire	100	100	100	Highly Valid	Very suitable for use without revision
4.	Teaching Module	78,1	91,1	81,3	Highly Valid	Very suitable for use without revision

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Table 3. Instrument Reliability Results Data

No	Instruments	Number of Items	Cronbach's Alpha	Criteria
1.	Pretest	6 grains	0,821	Reliabel
2.	Posttest	6 grains	0,847	Highly Reliable
3.	Student Response Questionnaire	10 grains	0,856	Highly Reliable

Data Collection

Data collection was carried out through giving *a pretest* to both classes before learning began to identify students' initial ability to understand geometry concepts. Furthermore, the experimental class was given treatment in the form of ethnomathematical learning with basic taekwondo techniques, where students learned geometry concepts through observation and direct practice of basic taekwondo movements such as easse, kicking, and parrying. In this lesson, the movement of the stance is used to contextualize the concepts of parallel lines and intersecting lines, the position of the feet on the kick is used to represent various types of angles, and the body posture pattern is modeled as a flat build, especially triangles. The learning process is designed so that students can relate the experience of movement to mathematical concepts through contextual discussion and problem-solving. After the learning ended, *a posttest* was given to both classes to measure the improvement in students' understanding of geometry concepts after receiving the treatment. In addition, student response questionnaires were distributed to experimental classes to find out students' responses to ethnomathematics learning based on basic taekwondo techniques that had been implemented.

Figure 1. Giving Research Pretest Questions

Table 4. Pretest Average Score Recapitulation

Classes	Average
Experiment	10
Controls	11,25

Figure 2. Learning Process

Figure 3. Giving Research Posttest Questions

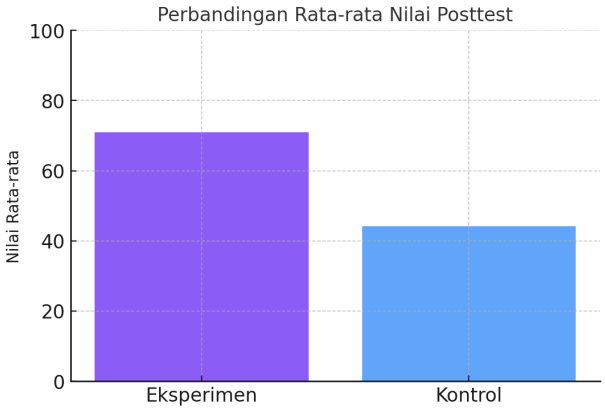

Figure 4. Posttest Score Comparison Chart

Data Analysis

Data analysis in this study was carried out in stages to test the improvement of students' understanding of geometry concepts and the difference in learning outcomes between the experimental class and the control class. The first stage is descriptive statistical analysis which is used to describe the data of pretest and posttest results in both classes. The descriptive statistics calculated include mean values, minimum values, maximum values, and standard deviations. This analysis aims to provide an overview of students' initial abilities as well as changes in learning outcomes after learning treatment is given. The second stage is the calculation of improved learning outcomes using the N-Gain test. This test is carried out by comparing *the pretest* and *posttest* scores of each student to find out how much there is an increase in understanding of geometry concepts after the learning process. The N-Gain values obtained are then classified into low, medium, or high categories according to the interpretation guidelines used. The research needs to first undergo testing to verify the requirements of the analysis, namely the normality test and the homogeneity test, with the aim of ensuring that the data meets the assumptions required in the use of parametric tests.

Research Findings and Discussion

The results of the study were obtained by giving the initial test and final test to both groups, namely the experimental class and the control class, which aimed to measure the level of students' understanding of geometry concepts before and after the learning process was carried out. Based on descriptive statistical analysis, the average *pretest score* in the

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experimental class was 10.00, and in the control class was 11.25. After the learning treatment, the average posttest score *of the* experimental class was 72.50 and the control class was 45.25.

Table 5. Descriptive Statistics of Prestest and Posttest Scores.

Classes	N	Pretest (Mean)	Posttest (Mean)	Standard Deviation
Experiment	20	10,00	72,50	10,84
Control	20	11,25	45,25	7,62

Carrying out hypothesis testing, first an examination of the prerequisites for data analysis. The normality test performed using *the Shapiro-Wilk* method yielded a significance value of 0.412 in the experimental class and 0.533 in the control class. Taking into account that both values exceed the 0.05 threshold, it can be concluded that the data is normally distributed.

Table 6. Normality Test Results (Shapiro-Wilk)

Classes	Statistic	Sig. (p-value)	Remarks
Experiment	0,958	0,412	Normal
Control	0,767	0,533	Normal

Furthermore, the homogeneity test was carried out using *Levene's Test.* The results of the analysis obtained a significance value of 0.364. Given that the value is above the threshold of 0.05, it can be concluded that the variance in both classes is homogeneous.

Table 7. Descriptive Statistics of Prestest and Posttest Scores.

Variable	Levene's Test	Say.	Remarks
N-Gain	0,842	0,364	Homogeneous

To find out the magnitude of the level of improvement in students' understanding of geometry concepts, an analysis of N-Gain test data was carried out. The results of the analysis showed that the average value of N-Gain in the experimental class reached 0.66 or equivalent to 66% which was included in the medium category. Meanwhile, in the control class, an average N-Gain value of 0.36 or 36% was obtained, which was included in the low category.

Table 8. N-Gain Calculation Results

Classes	Average N-Gain	Percentage (%)	Category
Experiment	0,66	66%	Medium
Control	0,36	36%	Low

Independent Sample t-Test which aims to identify differences in improved understanding of geometry concepts between the experimental class and the control class. Based on the test results, a t-value of 9.214 was obtained with a degree of freedom (df) of 38 and a significance value (2-tailed) of 0.000 at a significance level of 0.05.

Table 9. Independent Sample T-Test Results

Variable	t	Df	Sig. (2-tailed)	Mean Difference
N-Gain	9,214	38	0,000	0,300

As a result of data collection and analysis, it was obtained that the average N-Gain value in the experimental class was 0.66 which was included in the medium category, while the control class obtained an average N-Gain value of 0.36 which was included in the low category. In addition, the results of the Independent Samples t-test showed a significance value of 0.000

which was below the 0.05 threshold, thus identifying a significant difference in the improvement of understanding of geometry concepts between the two classes. Based on these findings, it can be concluded that the application of ethnomathematical learning methods that use taekwondo techniques as a foundation has a positive influence on improving students' understanding of geometry concepts when compared to conventional learning methods.

The findings of this study reinforce the view that geometry learning will be more effective when presented contextually and meaningfully through students' real experiences. The ethnomathematics approach allows students to build an understanding of geometric concepts through the relationship between mathematics and culture, as stated by Prahmana & D'Ambrosio (2020) that mathematics cannot be separated from the cultural practices of society (Sari, et al., 2023). The findings of this study align with previous research stating that the ethnomathematics approach is effective in improving understanding of geometric concepts, such as research by Naitili & Nitte (2023) and Mulyasari et al. (2021) which integrated traditional games into learning. However, this research presents a novelty by utilizing the martial art of taekwondo as a cultural context, which has not been widely explored in mathematics learning, especially at the junior high school level.

The integration of basic taekwondo techniques in geometry learning provides a learning experience that simultaneously involves physical, visual, and kinesthetic activities. The results of this study are in line with the foundation of constructivistic learning theory which emphasizes that knowledge is formed through direct experience and active involvement of students. Taekwondo movements that present lines, angles, and triangles help students visualize abstract concepts in concrete terms, thus strengthening conceptual understanding. This finding supports the research of Prahmana & D'Ambrosio (2020) which states that cultural context can help students associate geometric concepts with real representations, as well as strengthen students' cognitive structures.

The novelty of this research lies in the use of basic taekwondo techniques as an ethnomathematical medium that is not only used as a cultural context, but also as a means of movement-based learning. This approach provides an innovative alternative to geometry learning by integrating elements of local culture, physical activity, and mathematical concepts in an integrated manner. Thus, this study expands the learning of ethnomathematics that previously focused more on traditional games or cultural artifacts, and shows that martial arts have significant potential as a tool for contextual, engaging, and meaningful mathematics learning.

Conclusion

Ethnomathematics learning that applies basic taekwondo techniques has been proven to improve the understanding of geometry concepts for junior high school students through a more meaningful and contextual learning process. Through the relationship between taekwondo movements and geometry concepts, students can build a more concrete understanding so that they do not only rely on memorizing formulas. This approach suggests that the integration of culture and physical activity can be an effective alternative strategy of geometry learning. This research makes a significant contribution to expanding the understanding of ethnomathematics by presenting the martial art of taekwondo as a cultural background that has potential in the mathematics learning process. Nonetheless, the study still shows some significant shortcomings. First, the way of mapping the movements of the basic techniques of taekwondo into geometric concepts focuses more on visual and kinesthetic representations, so that in-depth mathematical analysis, especially in terms of proof and generalization of concepts, has not been

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fully revealed. Second, student participation in physical activity requires effective classroom management; If not managed properly, students' attention can shift from mathematical goals to focusing on physical activity alone. Third, success in the learning process is highly dependent on the teacher's ability to relate cultural context and mathematical concepts in a balanced way, so this approach can produce different understandings if applied by teachers who have diverse backgrounds or experiences. For this reason, future research is recommended to formulate a more structured learning design, develop aspects of students' mathematical reasoning in more depth, and test the consistency of the application of this approach in the classroom and more varied mathematics materials.

Conflict of Interest

The author emphasized that during the implementation, analysis, and reporting of the results of this research there were no conflicts of interest, both financial and non-financial.

Auhor Contributions

A.S.N plays the role of the main researcher who understands and formulates research ideas, carries out data collection, conducts data analysis, and prepares initial drafts and revisions of papers based on the results of the thesis. M.Z. contributes to the development of theoretical frameworks and research methodologies, guidance on data analysis, and the review and improvement of manuscripts. F.N.S and S.I.H. play a role in providing critical review, academic input, and suggestions for improvement to the substance and systematics of paper writing as examiners. All authors stated that they were late in agreeing to the final version of this paper. The percentage of each author's contribution in conceptualizing, writing, and editing the paper is as follows: A.S.N.: 40%, M.Z.: 30%, F.N.S.: 15%, and S.I.H.: 15%.

Data Availability Statement

Supporting data for the results of this study can be obtained from the corresponding author, A.S.N., as per reasonable request, as stated by the author.

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