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Ethnomathematical exploration of the *Remo* dance as a source for mathematics learning

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Abstract

Mathematics and dance are connected to both content and processes. This research aimed to explore *Remo* dance elements of movement, fashion accessories, and accompanying musical equipment as sources of mathematics learning. This ethnographic study was conducted at one of the oldest dance studios in the Kediri district. The research subjects were three Remo dance experts, consisting of a studio owner and two professional *Remo* dancers. Data were collected by interviewing the sources and observing and documenting dances. The data analysis uses triangulation based on the results of observations, documentation, and interviews. The exploration of mathematical concepts found in *Remo* dance was then analyzed using interrater reliability based on the agreement of three mathematics education experts. The results revealed 17 mathematical concepts in the Remo dance exploration of movement elements, fashion accessories, and accompanying musical equipment with almost perfect reliability categories. As a mathematics learning source, the Remo dance context can be applied to learning activities, preparing materials, and preparing test instruments.

Keywords: Ethnomathematics; interrater reliability; mathematics learning sources; *Remo* dance

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Introduction

Ethnomathematics explores the relationship between mathematics and cultural traditions, showcasing how mathematical concepts are integrated within various cultural contexts (Meaney et al., 2021; Milton & Orey, 2016; Rosa et al., 2016). By integrating cultural elements with mathematical principles, ethnomathematics fosters a more inclusive and relatable educational environment, making math more accessible and engaging for students from diverse backgrounds (Harding, 2021). The cultural context in ethnomathematics is crucial as it connects students' cultural heritage and experiences with academic knowledge, leading to a deeper understanding and appreciation of mathematics (Machaba & Dhlamini, 2021). Therefore, ethnomathematics links cultural knowledge with enhancing comprehension and its relevance in daily life.

One of cultural context that linked with mathematics is dance. Dance and mathematics are linked in specific ways, such as spatial and representational skills (Pálinkás-Molnár & Bernáth, 2020). Watson (2005) discovered four aspects of mathematics related to dance: spatial exploration, rhythm, structure, and symbolization. In the movement of a dance there are also various applications of mathematical concepts such as probability, combinatorics, shapes, and trigonometry as shown in Figure 1 (Gerofsky, 2013). Many dance choreographers apply mathematical concepts to analyze and create movement in dance (Mui, 2010). The relationship between dance and mathematics, as demonstrated through kinesthetic activities, has a positive impact on learners' comprehension of mathematical concepts and enhances their motivation (Evangelopoulou, 2014). Learning mathematics through dance enhanced critical thinking and creativity skills by assimilating abstract concepts with concrete movements (Leandro et al., 2018; López et al., 2022).

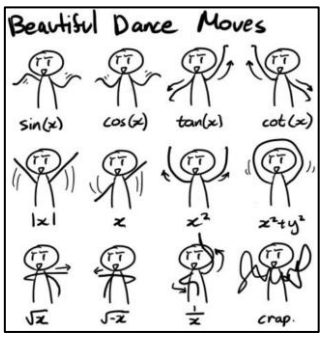


Figure 1. Mathematics and dance relationship on trigonometry

Various fields of study in ethnomathematics related to traditional dance are developed in mathematics education research. The research conducted by Dominikus et al. (2024) found the mathematics concepts of addition, multiplication, geometry, and arithmetic sequences in the *Ledo Hawu* Traditional Dance. Also, Hariastuti et al. (2021) identified mathematical concepts in motion variations. These concepts include counting numbers in all motions, number patterns in footwork, angles in all motions, and position of the object based on the compass point in footwork and body motions. The exploration of *Saman* dance, a traditional dance from Aceh,

reveals the incorporation of mathematical concepts in the opening ceremony of the 2018 Asian Games. Maryati and Pratiwi (2019) noted the presence of shapes and sets. Likewise, Ma'rifah et al. (2019) demonstrated the implementation of a kite shapes in the *Kejei* dance from Rejang Lebong District. Furthermore, research has been conducted on mathematical concepts' integration in dance, such as the *Barongan* from Blora and the *Malangan Topeng* dance (Nurina & Indrawati, 2021; Rahayu et al., 2019). These studies demonstrate the correlation between cultural dance forms and mathematics concepts in school learning.

Indonesia is renowned for its diverse cultures, including dances, musical instruments, paintings, and literary works. One of these is the *Remo* Dance, which is a typical dance from East Java that depicts the story of a brave prince during war (Rohayani, 2006). This dance is commonly performed as an opening act in *Ludruk* art performances, as a welcoming dance for guests, to celebrate events, and even in dance competitions (Basri & Sari, 2019). *Remo* dance combines choreography, fashion accessories, and accompanying musical equipment. Each region in East Java has its own unique characteristics in terms of movement and fashion accessories (Magdalena, 2015).

Remo dance has been explored as a learning resource in various fields, including physics, computer science, and the arts (Dawana et al., 2023; Indarti et al., 2023; Zaman et al., 2020). However, its potential for mathematics learning has not been extensively explored. Salsabilah and Indrawati (2021) used *Remo* dance from Jombang as a source of mathematics learning, focusing on dance movement elements related to angles and rotations. Damayanti and Mariyana (2023) explored the use of *Remo* dance movements in mathematics education, specifically for teaching counting operations and introducing shapes. Similarly, Yuliani (2022) investigated the use of Remo dance movements to introduce angle concepts and dance properties to introduce space concepts to elementary school students. The previous studies did not mention the specific angles and shapes generated from each dance movement observation. Besides, these studies did not explore the potential of fashion accessories and musical accompaniment as resources for mathematics learning.

This research will explore mathematical concepts in the typical Kediri Remo dance art, including elements of dance movements, fashion accessories, and musical equipment as a source of learning mathematics. The mathematical concepts from the exploration results in the Remo dance will then be analyzed with interrater reliability by experts in the field of mathematics education to determine their validity if used as a learning resource. The appropriate learning resources in mathematics learning activities can help students understand mathematics concepts using their experience and prior knowledge related to the context. It can also give students broader insight into ethnomathematics application in their culture. Therefore, the results of this study can be used as a learning resource that supports mathematics learning while introducing local culture related to ethnomathematics.

Methods

Ethnographic research with a qualitative approach was carried out to explore the mathematical concepts contained in Remo's dance, including movement elements, fashion accessories, and natural accompanying musical equipment through trusted sources (Gall et al., 2003). According to Gall, the steps in ethnographic research are formulating research problems and selecting relevant cases, gaining entry or reliable sources, collecting data, and analyzing data. This research was conducted at one of the oldest dance studios in Mojoroto sub-district, Kediri district, East Java in June 2023. This dance studio was chosen because it has been established since 1984 and participates in various dance arts performances nationally and internationally. The subjects in this research were three Remo dance experts: the studio founder, an instructor, and a professional dancer at the dance studio. The research purpose and framework were explained to the subjects to provide sufficient and appropriate information.

The data in this research is primary data obtained through interviews with research subjects, observation, and documentation of activities (Creswell, 2014). Interviews were conducted with the studio owner and the dance instructor to obtain data on the historical, cultural and philosophical aspects of dance, philosophical aspects of each dance movements, fashion accessories, and accompanying musical equipment used. Observations were carried out on the dance instructor and dancer to confirm the results of the interviews by observing the dancers' movements, fashion accessories, and accompanying musical equipment. Meanwhile, documentation is carried out for the studio owner, dance instructor, and dancer by taking pictures and videos so that nothing is missed when making observations. To verify the validity of the data obtained, triangulation method was carried out by looking at the agreement from the results of interviews, observations, and documentation to answer the same research focus (Leavy, 2017; Mertens, 2015). In addition, data triangulation was also carried out by looking at answers to the same research focus from different sources (Cohen et al., 2018).

Furthermore, to test the validity of the mathematical concepts discovered by the researcher was done using Interrater Reliability, a research agreement used to equate perceptions between the researcher and three mathematics education experts from IAIN Kediri (Belotto, 2018; Gisev et al., 2013). Agreement between the experts is needed to conclude that the concepts found by the authors are appropriate (Landis & Koch, 1975). The assessment sheet uses scoring rubrics of a dichotomous answer, agree or disagree with each concept found (Jonsson & Svingby, 2007). The test of inter-rater reliability results from experts/experts used the *Gwets* AC_1 *Coefficient* (Gwet, 2014). The mathematical concept is reliable if $\alpha > .60$ based on the reliability criterion of agreement between raters (Landis & Koch, 1977).

Results

Based on the results of interviews, observations, and documentation, information was obtained regarding *Remo*'s philosophy, movements, fashion accessories, and musical equipment to accompany the dance. *Remo* dance has a philosophy of uniting the human self with nature in

life in the world which is based on human self-strength through dance movements. There are 8 main movements in the *Remo* dance, namely the *beksan lumaksono*, the *sesembahan pembuka*, the *kaki junjungan*, the *penghubung 1*, the *tangan gunting*, the *penghubung 2*, the *nyumprit*, and the *bumi langit*.

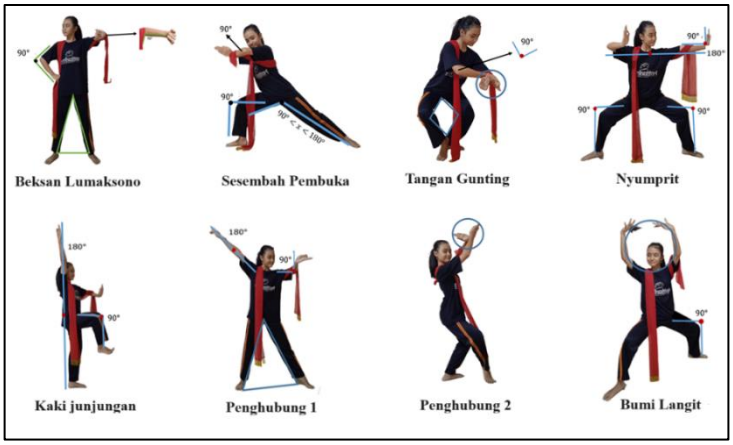


Figure 2. *Remo* dance movements

Each movement in the *Remo* dance (Figure 2) applies various mathematics concepts, especially in the geometry area (Table 1).

Table 1. Mathematics concepts on Remo dance movements

Mathematics Concepts	Dance Movements	Description
Isosceles triangle	*Beksan lumaksono* and *penghubung 1*	The concept of the isosceles triangle in the *beksan lumaksono* movement and *penghubung 1* is formed from 2 legs that are the same length and the distance between the two legs. It can also be expanded to the concepts of congruence and similarity.
Right angle	*Beksan lumaksono, sesembah pembuka, penghubung 1, kaki junjungan, nyumprit, tangan gunting,* and *bumi langit*	The concept of a right angle found in the *beksan lumaksono* and *penghubung 1* movements is from the movement of the bent arm with the elbow as the central angle. In the *nyumprit* movement, it is found between the forearm and palm with the center of the wrist. Meanwhile, in the *sesembahan pembuka*, the *kaki junjungan*, and the *bumi langit* movements are found in the crease between the calf and thigh at the center of the knee.
Obtuse angle	*Sesembah pembuka*	The concept of an obtuse angle in the worship movement is formed from the two legs forming a stretch that is more than a right angle but does not form a straight line.
Lines	*Nyumprit* and *kaki junjungan*	The concept of a straight line in the *nyumprit* movement is formed from a stretch of 2 hands which must be straight and equally high. Meanwhile, the *kaki junjungan* movement is from the hand waving upwards parallel to one of the straight legs' movements.

Mathematics Concepts	Dance Movements	Description
Rotation	*Tangan gunting* and *penghubung 2*	The concept of rotation in the *tangan gunting* and *penghubung 2* movements is formed from the two palms meeting and then rotating.
Circle	*Bumi langit*	The circle concept in the *bumi langit* movement is formed in the circular movement of hands meeting above the head.
Rhombus	*Tangan gunting*	The rhombus concept in the scissor hand movement is formed from both legs bent and the heels joined.

There are 7 mathematical concepts from the exploration of the 8 main *Remo* dance movements (Table 1). The concept of right angles is the most concept found in *Remo*'s 7 dance movements, both movements involving the hands and feet. Meanwhile, the *tangan gunting* movement is the movement that applies the most mathematical concepts, namely right angles, rotation, and rhombus shapes.

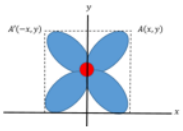
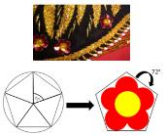
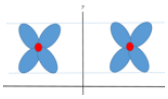
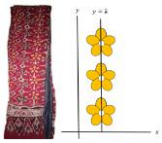
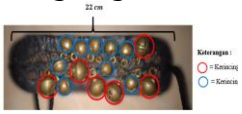
As a series of complete dances, the *Remo* dance uses seven types of fashion accessories, namely *udeng* worn on the head, *kace* as clothes, *keris* worn on the waist, *cinde* belt to tie the *jarik* cloth, *jarik* cloth to cover the lower part of the body, *sampur* as a complement to the clothes, and gongseng to held (Figure 3).

Figure 3. *Remo* dance accessories

The results of mathematical concepts exploration in *Remo* dance accessories are not only about the shape of the accessories but also include the shape of the accessory's components.

Table 2. Mathematics concepts on *Remo* dance accesories

Mathematics Concepts	Dance accessories	Description
Triangle	*Udeng* 	At the top of the *udeng* there is a triangular decoration which can be used to introduce a triangle. Exploration can also teach the perimeter and area of a triangle.
Rectangle	*Sampur* 	The shape of the *sampur* cloth resembles a rectangle and can be used to identify rectangles based on their characteristics. This concept can be explored regarding the rectangle's area, congruence, and similarity.

Mathematics Concepts	Dance accessories	Description
Reflection	*Kace* 	The concept of reflection on *kace* is depicted in the blue flower decoration on the chest with a red dot as the center for reflection.
Rotation	*Kace* 	The concept of rotation in floral motifs in *kace* decoration lies in the rotation of each flower petal with the center point is $(0,0)$. The rotational displacement of each petal is $72°$.
Translation	*Kace*  *sabuk cinde*  *kain jarik* 	The concept of translation found in *kace* can be seen in the floral motif's creation on the upper right and the upper left sides (see Figure 3). The translation concept for the *cinde* belt can be seen in the yellow flower design that decorates the belt. Each design is translated several times. Meanwhile, the concept of translation in the *jarik* cloth is found in the mountain-shaped decoration that decorates the edge of the *jarik*. Each design is translated repeatedly along the sides of the finger.
Proportion	*Gongseng* 	The concept of proportion found in *gongseng* can be seen in the size of the small *krenceng* (blue circle) and the large *krenceng* (red circle) concerning the material it is made from.
Pattern	*Sampur* 	The concept of number patterns is found in the *sampur* decoration consisting of large and small beads as well as leaf-shaped composition tips that can be represented in the pattern.
Curve	*Keris* 	The concept of curved lines can be found on the side of the *keris* that curved from base to tip. Exploration can lead to the concept of curved function graphs.

There are found 8 mathematics concepts from the exploration result of 7 *Remo* dance accessories (Table 2). The concept of translation is the concept that is most frequently found in the 3 *Remo* dance accessories. Meanwhile, *kace* is the accessory that applies the most mathematical concepts, especially transformation, namely reflection, translation, and rotation. Moreover, as part of the Remo dance series, there are musical instruments used in the dance consisting of *saron*, *bonang*, *kenong*, *gong*, and flute (Figure 4).

Figure 4. *Remo* dance musical instruments

The results of mathematics concepts exploration from *Remo*'s dance accompaniment musical equipment are presented in Table 3.

Table 3. Mathematics concepts on *Remo* dance musical instruments

Mathematics Concepts	Dance musical instruments	Description
Similarity	*Saron*, *bonang*, and *kenong*	The similarity concept in *saron* and *bonang* is found in the differences in the sizes of the *saron* and *bonang* components that are symmetrical to produce various scales. Further exploration can be used to compare the manufacturing materials.
Arithmetic pattern and sequences	*Saron*	The concept of patterns and sequences of arithmetic numbers found in *saron* is formed from the differences in the size of each component but similar in shape to produce different tones.
Circle	*Gong*, *bonang*, and flute	The circle concept found in *gong* and *bonang* musical instruments is formed from the surface, while in the flute it is formed at the tip and hole of the flute.
Sphere	*Gong*, *bonang*, and *kenong*	The sphere concept in *gong*, *bonang*, and *kenong* is found in a small protruding on the center of the instrument. The differences in the size of the protruding produced different tones.
Tube	*Seruling* (Flute)	The concept of a tube is found in the flute because its shape has elements of 2 circles on both sides and a rectangular structure surrounding it.

There are 5 mathematical concepts discovered from the exploration of 5 musical instruments that accompany Remo's dance. The *saron*, *gong*, and *kenong* musical instruments apply 3 mathematical concepts. Overall, there are 7 mathematics concepts found in *Remo* dance, 8 from fashion accessories, and 5 from accompanying musical equipment. A total of 20 mathematical concepts found in the *Remo* dance were then assessed for agreement by 3 raters.

Table 4. Rater agreement on mathematics concept from *Remo* dance

Rater assessment	R1	R2	R3
Agree	19 concepts	18 concepts	20 concepts
Disagree	1 concept	2 concepts	0 concept

According to Table 4, the rater agreement on the mathematics concept found in *Remo* dance is different. R1 did not agree with the finding of the concept of rotation in *the tangan gunting* and *penghubung 2* movement because, without a moving image, the concept of rotation could not be seen. R2 did not agree with the finding of the right angles concept in various movements and the circle's concept in the *bumi langit* movements. R2 considered that the movement might not form a 90^0 angle and not form a circle. The position of the feet in the *nyumprit* and *bumi langit* movements is more appropriate for teaching the concept of obtuse angles. The results of testing interrater agreement with *Gwets* AC_1 *Coefficient* show that the mathematical concepts found in the *Remo* dance ($\alpha = .999$) are included in the almost perfect category (Landis & Koch, 1977). The right angles concept found in several *Remo* dance movements is reduced only to the hand position of the *nyumprit* movement and the foot position of the *kaki junjungan* movement. Meanwhile, the concept of a circle formed from the movement of the bumi langit was eliminated because not all dancers could form a perfect circle. Thus, there were 17 mathematical concepts in the *Remo* dance that were agreed upon by the raters.

Discussion

The exploration results of mathematical concepts found in the *Remo* dance are mostly related to geometry. Movement elements, fashion accessories, and accompanying musical equipment have concrete shapes and dimensions. This follows the definition of geometry as more than just the science of proof but about visualization of shapes and spaces (Hoffer, 1981). Furthermore, the results of interrater reliability showed that the concepts found were in line with existing theory. This indicates that the *Remo* dance contains elements of ethnomathematics because of an agreement between researchers and experts (Cho et al., 2006). Assessment by many raters makes it possible to validate the findings so the results can be better (Hill et al., 2012). The results of the assessment agreement between raters can be a reference for validating research results, not only in the development of an instrument or teaching materials.

The mathematical concepts found in the *Remo* dance are related to various materials such as shapes, spacial, comparisons, geometric transformations, lines and angles, congruence, and number patterns. These results support research from Gazanofa and Wahidin (2023), who discovered the concepts of angles, straight lines, shapes, distances, and point coordinate systems. Several other studies also show a connection between dance and mathematics, such as geometry, numbers, algebra, and probability (An et al., 2019; Turmuzi et al., 2022; Wardani et al., 2023). The concepts found can be used for learning geometry on the thinking level of recognition, analysis, and logical ordering (Fuys, 1985). These levels include the ability to recognize objects from its shape, name the components of objects, carry out measurements and analysis, formulate definitions, and link relationships between various objects (Wirszup, 1976).

The concepts related to shapes and angles found in the *Remo* dance movements provide learning opportunities in the shapes and angles introduction based on the characteristics (Fitriani, 2022; Sa'adah et al., 2021). Meanwhile, concepts related to shapes, similarity, and patterns found in fashion accessories and accompanying musical instruments provide space for

cross-element learning in learning outcomes regarding circumference, area of polygon, and problems related to the similarity of 2 shapes and different sizes of components of a musical instrument to produce correct tones related to arithmetic patterns and sequences. Furthermore, the potential for cross-element learning can also be developed from concepts related to spaces and comparisons found in clothing accessories and musical instruments accompanying the *Remo* dance regarding the introduction of spaces, characteristics of spaces, surface area of spaces, volume of spaces, and problems related to the comparison of building volumes as per research by (Luthfi & Rakhmawati, 2022).

Exploring the concept of spaces by linking it to the patterns concept in accompanying musical instruments provides a learning space using the problem of material requirements for making accessories and making musical instruments to produce correct tones from different sizes. Meanwhile, the geometry transformation material found in the *Remo* dance accessories provides the potential for learning about an object's reflection, rotation, translation, and dilation to produce a computerize attractive designs. This is similar to the research findings from Sahara et al. (2024), who used a *Batik* context for learning geometric transformations for junior high school students.

The geometry learning design using ethnomathematics context can adapt Van Hiele's geometry learning instructions consisting of an inquiry phase, direct orientation, explicitation, free orientation, and integration (Van Hiele, 1959). Meaningful geometry learning can be done starting by designing a series of activities through games, including dance, which develops the geometric thinking of students (Van Hiele, 1999). Effective learning design and implementation can make it easier for students to understand concepts (Darling-Hammond & Baratz-Snowden, 2007).

Mathematics learning at school and the applications of mathematics that children find in daily life are often different (Hiebert & Carpenter, 1992). Teachers need to change the pattern of using problem contexts in mathematics learning that are close to students, such as games and culture (Dewah & Wyk, 2014). Connections between the *Remo* dance and mathematical concepts can make the *Remo* dance a source of learning mathematics based on the concepts found. Teachers can modify problems from the information contained in the Remo dance, including movement elements, fashion accessories, and accompanying musical equipment, based on the experience and knowledge of teachers and students to steer students in exploring mathematical concepts (Wager, 2012). Modifications can also be based on innovative learning strategies recommended by the curriculum to align with the learning course (Radite & Retnawati, 2023).

The concepts found in the Remo dance can be adjusted to learning achievement (*Capaian Pembelajaran/CP*) at each level of education (Kepala BSKAP, 2024). The introduction to shapes, angles, and characteristics of shapes can be applied to learning phases A and B. Meanwhile, the shape area, similarity, geometric transformation, comparison, and pattern concept can be implemented in learning phases C and D. The *Remo* dance can also be integrated into the *Projek Penguatan Profil Pelajar Pancasila/*P5 as new content in the national (*Merdeka*)

curriculum (Mendikbudristek, 2022). The project can explore *Remo* dance from different subject approach such as social science, cultural arts and language, music, and mathematics.

When carrying out a P5, especially dance, teachers can ask students to explore mathematical concepts applied to dance and explain the implication with the history of the dance. Activities carried out by students can start from observing mathematical concepts in dance, recording them, discussing them, and then working together to practice them (Vogelstein et al., 2019). In the case of the shapes and angles introduction, students can identify the dance movement that represents shapes and angles and then imitate the movement to verify (Trajkova & Cafaro, 2018). Mathematics learning and dancing activities combination can improve the ability to understand concepts, dance skills, and social skills (Nabie, 2015). This provides an integrating dimension of ethnomathematics into the curriculum, which is substantial for providing joyful and meaningful learning (Fouze & Amit, 2017).

Integration of dance context in mathematics learning can also be applied to dance-specific vocational schools where they are already familiar with dance movements and accessories. Using a familiar context understood by students and a proper learning design, it is hoped that mathematics learning can be effective and efficient in helping students understand mathematical concepts. Apart from that, teachers can also use the *Remo* dance context to create assessment instruments following the *Asesmen Kompetensi Minimum/AKM* (Indonesia National Assessment) and PISA frameworks, where one of the contexts used is the socio-cultural context of geometry and measurement content (Kemendikbud, 2022).

Conclusion

There are 17 mathematical concepts found in the *Remo* dance in various materials including angles, shapes, spaces, comparisons, transformation geometry, similarity and congruence, and patterns. The mathematical concepts found in *Remo* dance are included in the almost perfect category. These finding implied that interrater reliability might be used to validate research finding. Moreover, the *Remo* dance can be utilized as a context for teaching many mathematics concept as well as developing test instrument. The context of cultural elements as a source in mathematics learning hopefully can create meaningful and joyful mathematics learning activities that are close to students' daily lives and contain cultural values that can nurture students' character. This research was limited and did not develop mathematics learning materials or learning assessments in the *Remo* dance context. Therefore, future research opportunities are developing geometry learning material or learning assessments using the *Remo* dance as the context.

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Conflicts of Interest

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

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Author Contributions

Eka Sulistyawati: Conceptualization, methodology, writing, and editing; **Brenda Indah Nirmala:** Collecting data, analysis, and visualization; **Dewi Hamidah:** Translate, review and validation.

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