Characteristics of Ngremo Munali Fatah Dance Movements Using Biomechanical Analysis Through Motion Capture As Cultural Preservation

Afan Triyanto, The Graduate School of Universitas Gadjah Mada, Indonesia
Indraswari Kusumaningtyas, Universitas Gadjah Mada, Indonesia
Paramitha Fitriasari, The Graduate School of Universitas Gadjah Mada, Indonesia

Abstract

Ngremo Munali Fatah Dance is a traditional East Javanese dance that has cultural and aesthetic values. This study identifies the differences in motion characteristics in *Ngremo Munali Fatah* Dance for older generation and younger generation dancers, using Laban Movement Analysis (Shape) and biomechanics through motion capture as an effort to preserve culture. This research uses Rudolf Laban's theory of Laban Movement Analysis (LMA) Shape. This research uses Mixed Methods Research (Exploratory Sequential Design). Qualitative data was collected through LMA Shape to record differences in dance movement characteristics of older generation and younger generation dancers. Quantitative data was obtained from biomechanical analysis using motion capture. The results showed that *Ngremo Munali Fatah* Dance movement has distinctive characteristics between older generation and younger generation dancers, (1) measurement of biomechanical parameters such as joint angle, velocity and acceleration, and strength, (2) gesture, and (3) cultural preservation. This research makes an important contribution to preserving East Javanese culture by documenting the characteristics of traditional dance movements in detail and accurately. The results of this research can be used as dance learning materials, choreographic development, and cultural documentation.

Keywords: *Ngremo Munali Fatah Dance*, Traditional Dancer, Charactheristic, Laban Movement Analysis, Biomechanics, Cultural Preservation

iafor

The International Academic Forum
www.iafor.org

Introduction

Ngremo Munali Fatah dance was created by Munali Pattah, an artist born in Sidoarjo. *Ngremo Munali Fatah* dance has a form of movement and energy that emphasizes a calm, dashing (*pidhegsa*), straightforward, and broken appearance, stability of dance taste (*manteping rasa*), not insistent (not *ngoyo*), and firm. The attitude of *Ngremo Munali Fatah* dance is more upright (Wibisono, 2015, 116). *Ngremo Munali Fatah* dance is often learned and performed by various community groups. However, there are significant differences in the way the dance is learned and executed by older generation and younger generation dancers. These differences include, the learning process of older generation dancers by self-learning through observation and imitation who do not have access to formal training and tend to rely on personal instinct and creativity. This can result in movements that are more free and unique, but lack the technicality and precision of dance movements. Younger generation dancers, on the other hand, receive formal training and guidance from dance teachers through art education institutions or dance studios. Basically, they learn techniques that are standardized and refined through regular practice, resulting in more structured and consistent movements. Then several other factors, such as expression and style, technique and precision, as well as creativity and improvisation.

The main discussion that becomes a problem in this research is that there are differences in the characteristics of *Ngremo Munali Fatah* dance movements in older generation and younger generation dancers. This encourages differences in the characteristics of different forms of motion from the *Ngremo Munali Fatah* dance which previously experienced the development of dance movements for structural achievements. Therefore, the author seeks to identify in depth the differences in the characteristics of the *Ngremo Munali Fatah* dance movement form in older generation and younger generation dancers through the application of Laban Movement Analysis (LMA) Shape and biomechanical analysis using motion capture.

Theoretical Framework

Laban Movement Analysis (LMA) is a systematic method for observing, recording, and analyzing qualitative aspects of movement. According to (Habermen, 1970, 68) said that the Laban Movement Analysis Shape method is the most effective tool for describing differences between individuals in a particular cultural field and reality. The application of biomechanics can also be found in the field of dance with regard to dance movements. The use of this knowledge to analyze dancers' movements uses computer software that includes data through mechanical formulas. These formulas represent the application of mechanics in dance and can describe the characteristics of traditional dance movements for self-taught and younger generation dancers.

Methodology

This research uses Mixed Method Research which combines qualitative and quantitative methods (Creswell, 2003). This method starts with a qualitative method to explain the differences in the characteristics of *Ngremo Munali Fatah* dance movements, then uses a quantitative method to identify the differences in the characteristics of *Ngremo Munali Fatah* dance movements between older generation and younger generation dancers.

Result and Analysis

Laban Movement Analysis (Shape)

Understanding the basic concepts of laban analysis makes it possible to describe and analyze the qualitative aspects of movement, especially in dance styles that are known and mastered. Basically, changes in form can be divided into three changes in nature (Dell, 1977). The first change in nature is the flow of form which is the result of changes in the body and certain body parts. Then the second, the direction line is the embodiment produced by clear lines forming directions in space. Third, the embodiment of motion is the forms produced by the activities of the body in relation to space or adjustments to space, in Figure 8, as follows:
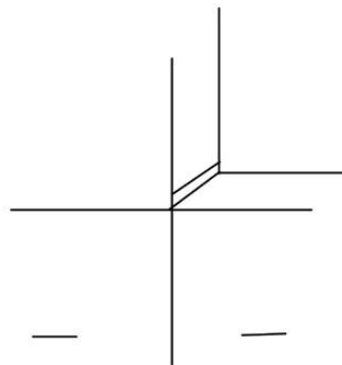

Figure 1: Form Diagram

The description of the diagram in Figure 1 is as follows, the two sloping lines at the crossing point of the horizontal and vertical lines are symbols of form. The horizontal line to the left of the crossing point is a symbol of the flow of form stretching, outward, away from the center, and expanding. The horizontal line to the right of the crossing point is a symbol of the flow of form of folding, inward, toward the center, and narrowing. The upright line from the crossing point is a symbol of high realization, while the downward one is a symbol of low realization, and a symbol of upward and downward direction lines. The upright line at the end of two sloping lines is a symbol of the realization of opening, and a symbol of the direction of the line to the outer side. The horizontal line at the end of two sloping lines is a symbol of the closing realization and a symbol of the inward sideways direction (Laban, 1971). The strip mark or connecting line to the left of the vertical line is a symbol of the forward realization and a symbol of the forward direction, while the one to the right of the vertical line is a symbol of the backward realization and a symbol of the backward direction.

Movement Analysis of "Ngremo Munali Fatah" Dance

Older Generation Dancer's "Lenggang Mundur" Motif.

Figure 2: Attitudes of the *Lenggang Mundur* Motif by Older Generation Dancer

Table 1: Description of *Lenggang Mundur* by Older Generation Dancers

| Count	Description Movement	Shape Symbol
five	*Lenggang Mundur* With the head extended to the left side, the face is turned to the left side and the gaze is far to the left side.	
five	The torso opens slightly to the left side at approximately 30 degrees. This is the effect of movements that are carried out simultaneously, with a standing position like a normal person walking.	
five	The right hand opens to the right side to form a perpendicular by opening from the center of the body 90 degrees, with the fingertips pointing downward and the palm facing inward and the back of the hand facing outward.	
five	The left hand opens by forming an elbow to the inner side. The fingers point sideways in the right direction with the palm facing forward and the back of the hand facing backward from the center of the body part.	
five	The right foot closes stepping close to the left foot as if walking.	
five	The left foot acts as a fulcrum so that the right foot can move and move closer to the left foot. The left foot stands upright like a person walking.	
six	With the head opening to the right side, the face is turned to the right side with a long gaze to the right side.	
six	The torso opens slightly to the right side at approximately 30 degrees. This is the effect of movements that are carried out simultaneously, with a standing position like a normal person walking.	
six	The right hand opens by forming an elbow to the inner side. The fingers point sideways in the left direction with the palm facing forward and the back of the hand facing backward from the center of the body part.	
six	The left hand opens to the left side to form a perpendicular by opening from the center of the body 90 degrees, with the fingertips pointing downward and the palm facing inward and the back of the hand facing outward.	
six	The right foot closes stepping close to the left foot as if walking.	
six	The left foot closes stepping closer with the left foot as if walking.	

Younger Generation Dancer's "Lenggang Mundur" Motif.

Figure 3: *Lenggang Mundur* Stance by a Younger Generation Dancer

Table 2: Description of *Lenggang Mundur* by Younger Generation Dancer

Count	Movement Description	Shape Symbol
Five	*Lenggang Mundur* The head faces to the left side following the direction of the sampur in the left hand.	
Five	The torso opens slightly to the left side at approximately 30 degrees. This is the effect of movements that are carried out simultaneously, with a standing position like a normal person walking.	
Five	The right hand is straight down at the right side of the body with the shape of the fingers and fingertips pointing downward, with the palm facing inward and the back of the hand facing the right outer side,	
Five	The left hand opens by forming an elbow to the inner side. The fingers point sideways to the right with the palm facing forward and the back of the hand facing backward from the center of the body, with the addition of clamping the sampur and dikebyok inward.	
Five	The right foot closes stepping closer with the left foot gejug in front of the left foot.	
Five	The left foot acts as a fulcrum so that the right foot can move and move closer to the left foot. The left foot stands upright like a person walking.	
Six	With the head opening to the left side, the face turns to the left side and the gaze turns to the left side.	
Six	The torso opens slightly to the left side at approximately 30 degrees. This is the effect of movements that are carried out simultaneously, with a standing position like a normal person walking.	
Six	The right hand opens to the right side to form a perpendicular by opening from the center of the body 90 degrees, with the fingertips pointing downward and the palm facing inward and the back of the hand facing outward.	
Six	The left hand opens by forming an elbow to the inner side. The fingers point sideways to the right with the palm facing forward and the back of the hand facing backward from the center of the body, with the addition of clamping the sampur and dikebyok inward.	

Six	The right foot closes stepping close to the left foot as if walking.	
Six	The left foot acts as a fulcrum so that the right foot can move and move closer to the left foot. The left foot stands upright like a person walking.	
Seven	With the head opening to the right side, the face is turned to the right side with a long gaze to the right side.	
Seven	The torso opens slightly to the right side at approximately 30 degrees. This is the effect of movements that are carried out simultaneously, with a standing position like a normal person walking.	
Seven	The right hand opens by forming an elbow to the inner side. The fingers point sideways in the left direction with the palm facing forward and the back of the hand facing backward from the center of the body part.	
Seven	The left hand opens by forming an elbow to the inner side. The fingers point sideways to the right with the palm facing forward and the back of the hand facing backward from the center of the body, with the addition of clamping the sampur and dikebyok inward.	
Seven	The right foot closes stepping close to the left foot as if walking.	
Seven	The left foot closes stepping closer with the left foot as if walking.	

Interpretation of Dance Movement Characteristics Results

Interpretation of the results of Laban Movement Analysis (Shape) shows the difference in movement characteristics between older generationic and younger generation dancers. The *Lenggang Mundur* motif in older generation dancers is identified that the nature of the flow of form is folding, inward, towards the center, and shrinking. Then the nature of the direction line is curved, and the embodiment is dominated by high and backward movements, and there are elements that stand out, namely low, closing, and backward. In younger generation dancers, it is identified that it is seen from the nature of the flow of form stretching, outward, away, expanding. Then the nature of the direction line is curved, and the embodiment is dominated by high, closing, and backward movements. It can be concluded that the nature of the form of older generation dancers is (contraction) and younger generation dancers are (expansion). Then the nature of the direction line between older generation and younger generation dancers has the same nature, namely the curved direction line. In the nature of realization, there are differences in the opening and closing parts of the movement in older generationic dancers that look balanced, but in contrast to younger generation dancers in the closing part of the movement is more dominant. The difference that is clearly visible at the beginning of the movement, it results in a difference in the prefix of the count of the *Lenggang Mundur* movement, namely the older generation dancer is earlier in doing the *Lenggang Mundur* movement, in contrast to the younger generation dancer who inserts a different initial motion before doing the *Lenggang Mundur* movement. On the left hand, older

generation dancers perform movements without using a *sampur,* but in contrast to younger generation dancers who use a *sampur* on the left hand in a series of *Lenggang Mundur* movements.

Based on the results of the Laban Movement Analysis (shape) analysis, it has a tendency to be able to identify the characteristics of the *Ngremo Munali Fatah* dance movement form in several parts of the dance, so there is an effort to continue the analysis of the characteristics of *Ngremo Munali Fatah* dance movement in older generation and younger generation dancers by continuing biomechanical analysis using motion capture focusing on analyzing joint angles, temporal or accentuation of dance movement, and strength in performing the characteristic movements of *Ngremo Munali Fatah* dance with laboratory testing using the Axis Studio application for sensor recording on the bodies of the two dancers as laboratory test samples, then from the recording results the analysis data is obtained from BoB Biomechanics which is continued by conducting kinematics analysis to identify differences in dance movement characteristics that are more accurate and comprehensive.

Biomechanics Analysis Using Motion Capture

From a biomechanical point of view, the body is viewed as a trunk connecting joints. Joints and their movements form the basis of analysis. Biomechanics studies measurable aspects of motion, such as speed and force, which can determine the elements of body movement (Nelson, 2000). The application of biomechanics in dance can be done using motion capture technology. Motion capture technology makes marks on the surface of the skin of the research subject (Rubiono, 2019). In this study using Axis Studio software version 1.3.10119.302. Some of the hardware used in this research, as follows:

Figure 4: Hardware PN Studio Sensor

PN Studio Sensor is a wireless nine-axis MEMS internal sensor focusing on integrated gyroscope, accelerometer, and magnetometer shown in Figure 4. It is designed to detect motion with high precision. The gyroscope is used to measure rotation, the accelerometer is used to measure acceleration, and the magnetometer is used to measure direction. The sensor is ideal for applications that require detailed motion analysis, such as ergonomic and sports research. PN Studio sensors come with a charging case that also serves as a charging and storage device. The charging case keeps your sensor ready and protected when not in use, increasing efficiency and mobility in the field.

Figure 5: Hardware Body Straps

Body Straps are special straps that allow the Preception Neuron Studio sensor to be securely and comfortably attached to a part of the artist's body shown in Figure 5. The body strap allows the sensor to be securely attached to key locations such as the wrist, waist, or thigh, enabling accurate and consistent motion measurement. This design facilitates customization and ensures the sensor remains securely attached without interfering with the viewer's natural movements during the recording and analysis process. Straps are used on the trainer according to the trainer for each segment. The installation of the sensor placement straps according to the previous diagram. Place the sensor into the base, then rotate the sensor 90 degrees clockwise. Press the sensor button on the top for about 2 seconds to turn on the sensor; Press the button for about 5 seconds to turn off the sensor. The sensor indicator light will display the status.

Analysis of *Ngremo Munali Fatah* Dance Movement

"Ayam Alas" Older Generation Dancer

Ayam Alas focuses on the footsteps to identify the strength of the right footsteps on the ground of the older generation dancer. The motif focuses on the data analysis of the right ankle Internal/External or right ankle rotation of the older generation dancer, which is shown in Figure 6, as follows:

Figure 6: Motion Capture Ayam Alas Result of Older Generation Dancer

Then the recording results in the Axis Studio software provide movement data processed in BoB Biomechanics. Biomechanics data includes aspects of joint angles between body

segments and time duration. The results of the biomechanics data to analyze the motion of the pedestal chicken are shown in Table 3, as follows:

Table 3: Footstep Data Results of the *Ayam Alas* Motif of Older Generation Dancers
(Source: Motion Measurement Data Through Biomechanics of
Bodie Software.Triyanto, 2024)

Time	Right ankle Int/Ext
09.01*	**135***
09.02	-1.615.651
09.03	-1.736.598
09.04	1.756.013
09.05	184.349
09.06	-172.875
09.07	180
09.08	1.659.638
09.09	-45
10	180
10.01	-1.659.638
10.02	-7.125
10.03	-1.693.803
10.04	140.362
10.05	0
10.06	1.779.546
10.07	0
10.08	0
10.09	-458.814
11	1.735.812
11.01	-802.038
11.02	1.362.189
11.03	-672.559
11.04	634.349
11.05	-172.875
11.06	-563.099
11.07	0
11.08	-90
11.09	-1.118.014
12*	**135***

"Ayam Alas" Younger Generation Dancer

Ayam Alas focuses on the footsteps to identify the strength of the right footsteps that tread on the ground of younger generation dancers. The motif focuses on the data analysis of the right ankle Internal/External or right ankle rotation of younger generation dancers, which is shown in Figure 25, as follows:

Figure 7: The Result of Motion Capture *Ayam Alas* Younger Generation Dancer

The recording results in Axis Studio software provide movement data processed in BoB Biomechanics. Biomechanics data includes aspects of joint angles between body segments and time duration. The results of biomechanical data to analyze the motion of *Ayam Alas* in younger generation dancers, are shown in Table 4, as follows:

Table 4: Footstep Data Results for the *Ayam Alas* Motif of Younger Generation Dancers
(Source: Motion Measurement Data Through Biomechanics of
Bodie Software. Triyanto, 2024)

Time	Right ankle Int/Ext
*15**	-531.301
15.01	0
15.02	-634.349
15.03	180
15.04	-1.640.546
15.05	0
15.06	180
15.07	-218.014
15.08	180
15.09	-336.901
16	45
16.01	180
16.02	336.901
16.03	-1.463.099
16.04	-265.651
16.05	-90
16.06	-135
16.07	45
16.08	0
16.09	-184.349
17	180

17.01	-135
17.02	180
17.03	-1.463.099
17.04	135
17.05	1.165.651
17.06*	***180****

Comparative Analysis of Dance Movement Characteristics

(a) Older Generation Dancer   (b) Younger Generation Dancer
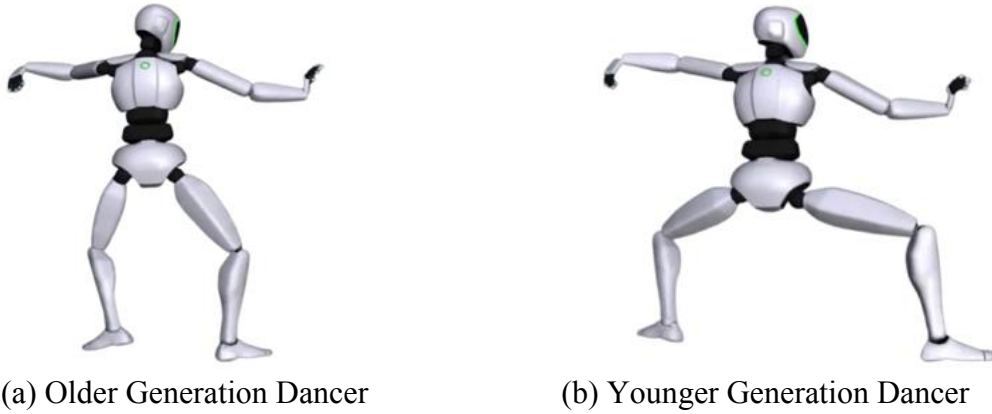Figure 8: Comparison of the Pose of the *Ayam Alas*

Right Knee Flexion/Extension Comparison

$$\Delta\theta = \theta_{younger} - \theta_{older} \qquad (1)$$
$$\Delta\theta = 0{,}0000000000477° - (-0{,}0000000000159°)$$
$$\Delta\theta = 0{,}0000000000477° + 0{,}0000000000159°$$
$$\Delta\theta = 0{,}0000000000636°$$

Larger joint angles in younger generation dancers of 0.0000000000477° may indicate the ability to perform movements with better control and precision, which may improve overall performance. Smaller joint angles in older generation dancers of 0.0000000000159° may indicate that the self-taught dancer may still be in the learning stage and may not have fully mastered the technique required to achieve the optimal position in the movement.

Comparison of Angular Velocity

Older Generation Dancer.

$$\omega = \frac{\Delta\theta}{\Delta t} = \frac{\theta_{end} - \theta_{beginning}}{t_{end} - t_{beginning}} \qquad (2)$$
$$\omega_{older} = \frac{0{,}0000000000954° - 0{,}0000000000318°}{11.07\ second - 09.01\ second}$$
$$\omega_{older} = \frac{0{,}0000000000636°}{2{,}06\ second} = 0{,}0000000000309°/second$$
$$\omega_{older} = 0{,}0000000000309°/second$$

Younger Generation Dancer.

$$\omega = \frac{\Delta\theta}{\Delta t} = \frac{\theta_{end} - \theta_{beginning}}{t_{end} - t_{beginning}} \quad (3)$$

$$\omega_{younger} = \frac{0{,}0000000000318° - (-0{,}0000000000636°)}{17{,}06 \; second - 15 \; second}$$

$$\omega_{younger} = \frac{0{,}0000000000954°}{2{,}06 \; second} = 0{,}0000000000463°/second$$

$$\omega_{younger} = 0{,}0000000000463°/second$$

From the comparison of the velocity results between the self-taught dancer and the younger generation dancer, we can draw the conclusion that the older generation dancer has an angular velocity of (0.0000000000309°/second). This indicates that the movement of the older generation dancer occurs more slowly or with smaller angular changes per unit time compared to the younger generation dancer. Then the younger generation dancer has a higher angular velocity, which is (0.0000000000463°/second).

Comparison of Angular Acceleration

Older Generation Dancer.

$$\alpha_{older} = \frac{\Delta\omega_{older}}{\Delta t} = \frac{\omega_{end} - \omega_{beginning}}{t_{end} - t_{beginning}} (5)$$

$$\alpha_{older} = \frac{0{,}0000000000309°/second - 0°/second}{11.07 \; second - 09.01 \; second}$$

$$\alpha_{older} = \frac{0{,}0000000000309 °/second}{2.06 \; second} = 0{,}0000000000150°/second^2$$

$$\alpha_{older} = 0{,}0000000000150°/second^2$$

Younger Generation Dancer.

$$\alpha_{younger} = \frac{\Delta\omega_{didactic}}{\Delta t} = \frac{\omega_{end} - \omega_{beginning}}{t_{end} - t_{beginning}} \quad (4)$$

$$\alpha_{younger} = \frac{0{,}0000000000463 °/second - 0°/second}{17.06 \; detik - 15 \; second} = \frac{0{,}0000000000463 °/second}{2.06 \; second}$$

$$= 0{,}0000000000225°/second^2$$

$$\alpha_{younger} = 0{,}0000000000225°/second^2$$

From the comparison of the angular acceleration between older generation and younger generation dancers, we can conclude that older generation dancers have an angular acceleration of (0.0000000000150°/$second^2$). This indicates that the change in movement speed of self-taught dancers occurs more slowly, meaning that older generation dancers may make slower movement adjustments over time. Then younger generation dancers have a larger angular acceleration, which is (0.0000000000225°/$second^2$).

Comparison of Footwork Power

$$F = m \times \alpha \quad (6)$$

Older Generation Dancer.

$$\alpha_{older} = \frac{\Delta\omega_{older}}{\Delta t} = \frac{\omega_{end} - \omega_{beginning}}{t_{end} - t_{beginning}}$$

$$\alpha_{older} = \frac{135\,°/second - 0°/second}{12\,second - 09.01\,second} = \frac{135\,°/second}{2.09\,second} = 64.60°\,m/second\,^2$$

$$F = m×\alpha \qquad (6)$$

$$F = 68\,kg×64.60\,m/second\,^2 = 4392.8\,N$$

Younger Generation Dancer.

$$\alpha_{younger} = \frac{\Delta\omega_{younger}}{\Delta t} = \frac{\omega_{end} - \omega_{beginning}}{t_{end} - t_{beginning}}$$

$$\alpha_{younger} = \frac{180\,°/second - 0°/second}{17.06\,second - 15\,second} = \frac{180\,°/second}{2.06\,second} = 87.38°\,m/second^2$$

$$F = m×\alpha \quad (6)$$

$$F = 53\,kg×87.38\,m/second^2 = 4631.1\,N$$

Older generation dancers produce a force (4392.8 Newton) when performing foot movements on the base chicken motif. This value shows that the force produced by the right foot of the older generation dancer is very large and close to the value produced by the younger generation dancer, shown in Figure 26 (a). Younger generation dancers produce a force of (4631.1 Newton) slightly greater than the force produced by older generation dancers. In terms of the amount of power there is no big difference, it appears that both dancers have relatively the same physical strength, shown in Figure 27 (b).

Conclusions

The use of Laban Movement Analysis (Shape) and biomechanical analysis is very effective in identifying differences in motion between older generation and younger generation dancers, which plays an important role in cultural preservation efforts. Laban Movement Analysis (Shape) which focuses on the elements of quality of motion form to recognize the characteristic shape of motion in each dancer. This helps identify differences in interpretation of movement, especially among older generation dancers who tend to be more free and exploratory than younger generation dancers who follow formal structures. Biomechanical analysis provides a deeper understanding of the efficiency and dynamics of body movement. It can reveal smaller technical differences between two dancers by measuring physical aspects such as joint angles, acceleration, speed and force. Older generation dancers experience changes in balance and force distribution that are different from those experienced by younger generation dancers with more structured formal training. Combining these two methods not only allows for more comprehensive identification of movement differences, but also provides detailed documentation for cultural preservation. This documentation based on scientific analysis provides flexibility in the development of dance over time, while maintaining the originality of traditional movements.

Acknowledgements

References

Creswell, J. W. (2003). *Research Design Qualitative, Quantitative, and Mixed Methods Approaches. Second Edition.* California: Sage Publications, Inc.

Dell, C. (1977). *A Primer for Movement Description Using Effort-Shape and Supplementary Concepts*. New York: Dance Notation Bureau Press.

Habermen, M. & Meisel, T. (1970). *Dance an Art in Academy*. New York: Teacher Collerge Press.

Laban, R. (1971). *The Mastery of Movement*. Boston: Plays, Inc.

Nelson, R. C. (2000). *Biomechanics of Human Motion: Applications to Rehabilitation, Sports, and Occupational Health*. Amerika Serikat: John Wilsey & Sons.

Nuryanto, H. & Ridlo'I, M. (2011). *Munali Patah Art Hero from Sidoarjo.* Sidoarjo: Dewan Kesenian Kabupaten Sidoarjo.

Rubiono, G., Finahari, N., & Qiram, I. (2019). *Dance Biomechanics*. Yogyakarta: K-Media.

Supriyanto, H. (2001). *Ludruk East Java.* Surabaya: Dinas P dan K Provinsi Jawa Timur.

Wahyudiyanto. (2008). *Heroism of Surabayan Ngremo Dance Reflection of Idea, Image and Identity Politics in Aesthetic Space.* Solo, Jawa Tengah.

Wibisono, T. B. (2015). *Ngremo Dance Notes from Stage to Stage.* Surabaya.

Contact email: afanromadlonfebritriyanto1996@mail.ugm.ac.id