Indonesian Journal of Music Research, Development, and Technology

Journal homepage: http://ejournal.upi.edu/index.php/interlude

Analyzing The Acoustic Behavior of Gamelan Music Performance in Different Environments

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ABSTRACT

This study examines the acoustic characteristics of Gamelan music performances in various settings, explicitly emphasizing the disparity between enclosed auditoriums and open spaces. Given the growing frequency of Gamelan performances in varied contexts, the comprehension of how diverse environments impact acoustic qualities is of utmost importance to enhance audience experience and safeguard the authenticity of traditional musical forms. The significance of this study arises from the increasing prevalence of Gamelan music in non-traditional contexts, such as outdoor festivals, prompting inquiries into the variations in acoustic properties across different situations. This research endeavor aims to fill the existing gap in knowledge by undertaking a qualitative examination of acoustic phenomena in enclosed and unobstructed environments. The research presented in this study is notable for its extensive investigation into acoustic phenomena across many settings, considering several aspects, including sound reflection, absorption, and reverberation. Qualitative analytical techniques were applied to evaluate the acoustic characteristics within each respective setting by utilizing a comprehensive examination of pertinent scholarly works pertaining to acoustics and Gamelan music. The findings suggest that closed auditoriums, which have controlled sound distribution and little interference, exhibit unique acoustic characteristics compared to open spaces. In open spaces, sound propagation is affected by ambient elements and the audience's presence. The research underscores the significance of architectural design in influencing acoustic surroundings and the necessity for flexible performance venues that can handle the intricacies of Gamelan music. This study makes a valuable contribution to the existing body of knowledge by providing a more comprehensive understanding of the impact of contextual elements on the acoustic characteristics of Gamelan music. The findings of this research have implications for the improvement of performance venues and the promotion of audience involvement in various contexts.

ARTICLE INFO

Article History:
Submitted/Received 27 Apr 2023
First Revised 27 Apr 2023
Accepted 30 Apr 2023
First Available online 15 May 2023
Publication Date 31 May 2023

Keyword:
Gamelan,
Acoustics,
Music performance,
Auditorium,
Space.

1. INTRODUCTION

Gamelan is an often-cited musical instrument. The term "karawitan" is prevalent throughout Indonesian society, particularly in gamelan (Kobi, 2017). The primary objective in the execution of gamelan or musical music is to deliver intrinsic gratification to the aficionado of this genre. Ensuring the satisfaction of the audience is of paramount importance. A gamelan must possess a melodic essence (Walton, 2007; Sutton, 1979). The essence of music Karawitan is a manifestation of auditory perception that harnesses internal strength to create a musical composition that lacks physical manifestation, is imperceptible and alone elicits emotional responses from both the musician and the audience (Pasaribu, 2013). Mark L. Benamou suggests that the term "rasa" in music can also be interpreted as "sensation" or "inner meaning." However, it can also refer to "the capacity to articulate or comprehend emotions or internal significance" or "the aptitude by which these are perceived" (Riyadi, 2013; Harwood, 2011; Walton, 2007). Feelings, in the context of music, can also be interpreted as the most profound sensation or comprehension (Perlovsky, 2010).

Nevertheless, it is worth noting that emotions might possess the significance of conveying or experiencing profound sentiments or the significance of a discussion, sometimes referred to as intuition (Magdalena et al., 2022). In order to provide a visually pleasing musical experience, it is crucial to consider the acoustics of the performing area during the event as it can elicit auditory perception of sound instruments, enabling the capture and processing of the auditory perception of the visual appeal of sound. Presenting music necessitates using physical space as a means of artistic expression for artists, which is subsequently consumed by the general public (Driver & Bennett, 2015). Additionally, musicians play and appreciate musical instruments. The presence of a harmonic performance room is a fundamental prerequisite for the enjoyment of live music (Hödl, et al., 2020). Three distinct forms of space performances can represent space: closed space, open space, and semi-open room (Philokyprou, et al., 2018). This article explores the role of space as a venue for the performance of gamelan. Two distinct categories of rooms exist, specifically closed space and open space. Before delving into the characteristics of the performance space, it is imperative first to analyze the propagation of sound in space. It is essential to understand the properties of sound waves. Wave sound exhibits characteristics similar to light waves since it bounces in response to changes in position (Toole, 2006). The angle of incidence is equal to the angle of reflection when the sound wave strikes an object that is perfectly smooth and has a larger area than the dimensions of the incoming sound wave (Quate, 1979). However, when the sound wave hits an object with a rough surface, it bounces in an irregular direction (Gaver, 1993). Additionally, when the sound wave hits objects of certain materials, it is absorbed and either forwarded or transmitted.

2. METHODS

This research uses a qualitative approach to analyze the acoustic behavior of Gamelan music performance venues in various environments, especially closed auditoriums and open spaces—qualitative methods used to capture different acoustic characteristics. The research began with an extensive literature review of scholarly sources and online databases, focusing on acoustics, architectural design, and Gamelan music studies. Several studies provide basic knowledge about the acoustic properties of Gamelan instruments and the influence of environmental factors on sound propagation. Internet sources, including academic journals, conference proceedings, and leading websites, were also consulted to gather additional

insights and perspectives. This holistic approach ensures a comprehensive understanding of acoustic phenomena in various performance settings. After the literature review, data collection included field observations. Observations were conducted at performance venues in closed auditoriums and open spaces to document acoustic characteristics such as sound reflection, absorption and reverberation. Through qualitative analysis of observational data and literature studies, this research aims to identify patterns, themes and unique acoustic features associated with each performance environment, thereby contributing to a deeper understanding of the acoustic behavior of Gamelan music in various settings.

3. RESULTS

According to Pelealu et al. (2015), music can be described as the scientific practice of creating musical notes and sequences of profound sounds. The process entails the creation of combinations and temporal linkages to generate a cohesive and uninterrupted sound composition (Heba, 1997; Garro, 2012). Music organizes sounds or vocals to include rhythm, melody, and harmony, mainly using technologies that may generate these sounds (Herremans, et al., 2017; McAdams, et al., 2004). Music, as an art form, employs sound, vocals, and silence as its medium to express a range of human emotions through a sequence of tones infused with rhythm, melody, and harmonic structures (Lissa, 1964; Lissa, et al., 1965). Inside the field of acoustics, the examination of spatial acoustics explores the manipulation of diverse auditory stimuli inside a designated area (Knudsen & Brainard, 1995; Tajadura-Jiménez, et al., 2010; Sutanto, 2015). Space acoustics focuses on managing and regulating sound waves as they engage with the surrounding physical environment (Coleman, et al., 2012), exerting an impact on their propagation, reflection, absorption, and diffraction (Every, et al., 2013). Comprehending the principles of space acoustics holds significant importance for professionals in architecture, engineering, and design, as it enables them to develop spaces tailored to accommodate diverse auditory encounters, be it in concert halls, recording studios, or public settings. Practitioners can enhance the clarity, richness, and immersive characteristics of musical performances by manipulating the acoustic features of a venue, thus increasing the listener's experience.

Gamelan, an indigenous musical group from Indonesia, embodies a harmonious amalgamation of music, culture, and communal manifestation. Gamelan, consisting of a wide range of instruments, represents the combined essence of its performers, with each instrument playing a role in creating a harmonious whole (Baranauskas, 2009). Gamelan holds great importance as a fundamental component of Indonesia's cultural legacy, reflecting the nation's diverse traditions and customs (Fatmawati, 2021). The ensemble's unique timbres and complex rhythms elicit a feeling of cohesion and collective identity, cultivating a profound bond with both the artists and the listener. Gamelan practice and performance are intricately connected to the environments in which they occur. Historically, gamelan ensembles convene in specific performance venues, frequently embellished with Historically, gamelan ensembles convene in specific performance venues, frequently embellished with melodic, rhythmic, and symbolic patterns (Bakan, 2016). These places function as havens for manifesting musical creativity, generating a feeling of camaraderie and inclusion among individuals involved.

Furthermore, the acoustic characteristics of the performance venue are of utmost importance in influencing the auditory environment of a gamelan ensemble (Serafini, 1995). The influence of the room's reverberant properties, instrument placement, and architectural architecture on the music's timbral richness and spatial depth is significant. Artists adapt their playing techniques and dynamics to the acoustic surroundings, meticulously refining their sound to get an ideal equilibrium and lucidity. Therefore, the performance venue assumes a crucial role in the ensemble's auditory repertoire, influencing the intricacies of expression and

the auditory qualities of the music (Brinner, 1999). Gamelan has extended its influence beyond traditional performance locations and has gained popularity in modern contexts, including music halls (Ramnarine, 2013), cultural centres, outdoor festivals, and academic institutions (Johnson, 2002). The various locations available offer opportunities to demonstrate the variety and adaptation of gamelan music, surpassing limitations imposed by geography and cultural differences. Gamelan, regardless of its location, possesses an innate ability to fascinate and inspire listeners, effectively connecting historical and contemporary contexts, as well as tradition and innovation (Philpott, 2018).

The convergence of music, acoustic space, and gamelan encompasses a complex interaction of artistic manifestation, cultural legacy, and spatial dynamics (Vitale, 2002). Gamelan practitioners establish relationships beyond simple musical performance by combining sound and space, promoting community, identity, and shared humanity (Marsh, 2019). The practice and performance of Gamelan, characterized by its intricate interplay of varied instruments and complex rhythmic patterns, pose distinct challenges and opportunities in spatial acoustics. Many problems frequently hinder the quality of rehearsals and performances in traditional gamelan practice locations.

Numerous practice locations exhibit rigid, reflecting surfaces that intensify reverberation and generate a pronounced dispersed auditory atmosphere. This phenomenon can pose challenges for members of an ensemble in perceiving distinct instrument timbres and rhythmic subtleties, hence resulting in problems related to intelligibility and the overall unity of the group. In order to tackle this difficulty, professionals may utilize acoustic interventions such as sound-absorbing panels, diffusers, and bass traps to alleviate undesired reflections and establish a more equitable and regulated acoustic setting (Lauria, et al., 2020; Arjunan, 2019). Moreover, current practice locations frequently need more space for ensemble members, impeding the musicians' capacity to listen and engage with each other effectively. Acoustic congestion can occur in crowded practice areas, causing sound waves from various instruments to interfere, resulting in a muddy and indistinct audio texture.

Examining the acoustic properties of gamelan music performance in various settings is crucial for comprehending the interaction between the sound attributes of the music and the surrounding environment. Gamelan practitioners frequently encounter difficulties in closed-room environments, such as typical rehearsal facilities, due to insufficient acoustic treatment, and restricted space. The limitations above can influence the lucidity, resonance, and equilibrium of the collective auditory experience, impeding communication and coordination among musicians. In order to effectively tackle these concerns, professionals must meticulously adjust the acoustic characteristics of the rehearsal area, employing strategies such as sound absorption, diffusion, and spatial arrangement optimization to establish a setting that amplifies the auditory lucidity and immersive nature of the music. The acoustic properties of gamelan music in enclosed spaces are affected by the physical attributes of the area, such as its dimensions, configuration, and surface materials (Gade, 2008). Concrete walls and tiled floors, which are hard and reflective surfaces, can worsen reverberation and produce a dispersed and unfocused sound environment. It can make it difficult for members of an ensemble to distinguish specific instrument timbres and rhythmic patterns. In order to address these consequences, professionals may employ acoustic interventions such as sound-absorbing panels, diffusers, and bass traps to regulate reverberation, reduce undesired reflections, and improve the lucidity and comprehensibility of the music.

Open-room settings offer distinct acoustic problems and opportunities for gamelan music performance instead of closed-room conditions. Open spaces, such as outside courtyards or

festival stages, provide more versatility in spatial arrangement and air circulation, facilitating the comfortable assembly of more prominent ensembles and spectators. The acoustic characteristics of gamelan music in open-room settings are subject to various influences, including ambient noise, wind, and temperature variations. These factors can affect the overall clarity and balance of the ensemble sound. In order to enhance the acoustic characteristics of gamelan music in open-room settings, it is imperative for practitioners to meticulously deliberate upon the positioning and alignment of instruments and performers in the surrounding spatial context. The deliberate placement of the group serves to mitigate the impact of surrounding noise and wind interference, guaranteeing the preservation of the music's clarity and audibility for the audience.

Implementing movable acoustic barriers, sound baffles, or tent structures can reduce environmental disruptions and establish a more regulated acoustic setting for rehearsals and performances (Klosak & Gade, 2008). Although outdoor locations provide difficulties, open-room environments provide distinct benefits for gamelan music performance, such as interacting with a broader audience and generating immersive, location-specific auditory encounters. The inherent acoustic properties of outdoor environments, distinguished by their vast views and unobstructed air, can augment music's resonance and spatial profundity. It, in turn, fosters a feeling of interconnectedness and unity among musicians, audience members, and the immediate surroundings. Outdoor performances additionally cultivate an atmosphere of inclusiveness and accessibility, extending an invitation to everyone passing by to partake in the captivating and dynamic nature of gamelan music inside unforeseen environments.

Examining the acoustic characteristics of gamelan music performance in several settings, including closed spaces, unobstructed spaces, and outdoor situations, yields significant findings regarding the intricate relationship between sound and spatial dynamics. Practitioners can increase the rehearsal and performance experience of gamelan music by comprehending the interaction between the music's auditory features and the environment's physical properties. This understanding allows for creating surroundings that improve the music's clarity, resonance, and immersive quality. Gamelan practitioners may create dynamic and engaging auditory experiences that resonate with audiences in various settings and contexts by paying close attention to acoustical principles, spatial design concerns, and practical conveniences.

4. DISCUSSION

The property of objects that reflect sound waves in closed and open spaces is considered remembering knowledge about nature and the movement of sound waves. The nature of the object that absorbs sound waves and the properties of the objects that emit them or sound waves (Cummer, et al., 2016). These differences can be understood from the two rooms as waves, character, and tone quality of gamelan instruments in both rooms.

4.1. Closed Space (Auditorium)

Walls and ceilings surround an enclosed space, like an artistic performance space or an auditorium (Beranek, 1992). An auditorium is a large room or building accommodating many people (Robinson, 1949). Auditorium comes from the word "audit", which means audience/researcher and rum means place, so it can be interpreted as a place where spectators gather to watch performing arts. The auditorium was also used for graduation events, seminars, and general lectures (Berrett, 2012). When talking about art standardization, performances such as music performance halls and concert halls should at least fulfil acoustic standard requirements, which aim to ensure that the appreciator enjoys and feels comfortable watching and hearing the performance (Pitts, 2005). The auditorium has good design factors, viz acoustic criteria for good sound and acoustic criteria influenced by shape, volume, and room dimensions (Beranek, 1992). Apart from these criteria, the venue settings, sitting appreciators, capacity, and material layers used for acoustic and interior architecture are also considered when designing the closed space (Ishak, et al., 2022).

An auditorium is a room that is quite complex; here are the requirements for good listening conditions in an auditorium (Ramakrishna, 1978):

1. There must be a reasonably deep loudness in each part of the performance building, especially at the front of the audience seating area from the stage.
2. Sound energy must be distributed smoothly and evenly in space.
3. The room must be free from acoustic defects such as echo, prolonged reflection, reverberation, sound concentration, distortion, sound shadows, and space resonance.
4. Noise and vibration will be annoying, and hearing or staging should be avoided or reduced in each part of the space.

These conditions must be met if someone makes an auditorium building.

Another factor to avoid in making this closed room (auditorium) is where sound repetition, sound concentration, prolonged reflection, and high background noise levels exceed the standard criteria for a type of performance. That creates obstacles to non-conformity characteristics of acoustic panels with sound acoustics gamelan instruments due to the permanently installed panels' nature rather than specifically for one particular type of ensemble. Several cases occurred due to the mismatch of all the acoustic panels being absorbent, so the distance of the original sound on stage is very short. So, the sound effect on stage is as if dead.

The actual results will be confused with the proper reflection if no absorbent acoustic panels are in the auditorium. So, the sound should stop immediately or, for too long, a resonance that is not desired; it will cover up weak sounds. Likewise, several instruments require reflection to propagate sound in the room because it is far from the characteristic walls. The sound sometimes sounds like it is coming and going or not audible throughout the audience seating area. It should also be noted that the auditorium has multi-function walls on the side and back of the audience. Even if an auditorium is built for musical performance, requirements are usually deep; the performance uses loudspeakers. Although amplification is sometimes necessary for some weak or vital instruments, it still needs to be added to the sound characteristics of the instrument gamelan (Indrani, 2004; Indrani, et al., 2007). It will also need to be clarified for the concert compositions; sometimes, they still need to be closer to the proper attributes of gamelan instruments. Thus, it will also disrupt the composition of the dish shown in its concerts, and sometimes, giving *ruh* (soul) is challenging.

4.2. Open Space (Outdoor)

The second space is an open space. Acoustic empty spaces or outdoors are more complex compared to acoustics in an enclosed space because there are many factors involved that interfere with hearing clarity, such as energy sound is a wave that travels through the air open, many sources of absorption sound in the form of waves propagating in the air open, many sources of sound absorption from disturbances caused by various activities.

The sound of gamelan instruments forms the spirit (soul) of palm music in open spaces because it exists low frequencies resulting from some instruments that have long vibrations (Surwadi, 2016). Among these instruments are *barung*, *panerus*, *slenthem, kenong, kempul,* and *gong*. The result of a sound with long vibrations and low frequency, making a grinding composition that is presented, is felt more unified than the instrument's overall sound. This is caused when the notes are hit with fast, medium, or slow rhythms. Unconsciously, it is still accompanied by low-frequency sounds with long vibrations. For low-frequency ones, the length is the tone that sounds early as if connecting to the notes following, and this incident applies to the tone further. Thus, the low frequency of the results of these long vibrations frames the sound notes and creates a sound. The composition of the piece has more shape and thick character.

Another experience of Western music knowledge is that a song composition always considers the sound of the instrument frame. As for the framing notes, the sound comes from the instrument, has a low frequency, and has long vibration (Mulyawan, 2022). Thus, every note sounds like an instrument in a composition presented; it doesn't feel like it stands alone. This composition requires long vibrations, or other terms called pad or drone, to combine related tones. Furthermore, the movement of sound is horizontal, spreading wider in all directions without any refraction by the right-side wall, left side wall, and front. The movement of sound spread horizontally will disappear immediately. In the sound produced by gamelan instruments in musical performances, the musical spirit (soul) will not appear correctly. Another thing is also caused by an audience sitting at the same height, parallel, and close together. On In this case, the audience becomes the media sound absorber. The sound-absorbing media found on the clothes worn, including the audience's hair, as with space open. Processes that form and bring the spirit (soul) of musical instruments because of the spread of sound moving vertically. There is an upward movement of sound vertically, which will again spread downwards because of the refraction of sound waves by the roof or *pendhapa* ceiling. The movement of sturdy upright in the *pendhapa* space is the opposite of the horizontal movement of sound. The following illustrates the movement of sound in the ceiling area.

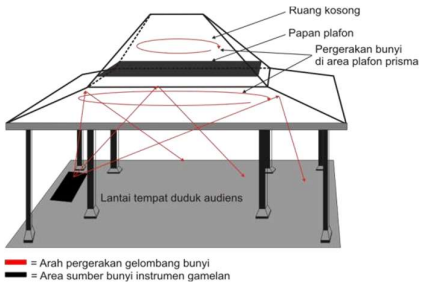

Figure 1. Schematic of the movement of sound waves in the ceiling and roof board area (Santoso, 2018)

In the description above, the sound source placed at the edge of the open space is a set of gamelan instruments. So, as discussed above, the reflected sound moves vertically so that the

process spreads evenly throughout the roof or ceiling area. Two sound propagation processes cause the vertical movement of sound to the ceiling or ceiling. Sound propagation occurs in two directions: through air (airborne noise) and through fixed components (structure-borne noise (Mediastika, 2005). Because the roof surface is rectangular and conical, the roof slope is ± 20º-45º to form a reflective wall. Reflective walls indirectly amplify sound and reflect sound. Continuous sound reflection in the ceiling creates a repeated reflection effect with a high reflection density, resulting in a long reverberation time. The occurrence of long reverberation times is also caused by the nature of the material used for the ceiling or ceiling panels, which is dense and complex and has a low level of sound absorption.

The entry of sound waves that occur above the ceiling board (space) due to gaps or holes in the ceiling through airborne sound propagation. Another thing is that sound waves enter space due to sound propagation through building elements (structure-borne sound).

Sound propagation occurs through elements building (structure borne sound) on the board ceiling because of the strong resonance that is influenced by the propagation of airborne sound, which hits the ceiling board directly (Song, *et al.,* 2016). Impact on the ceiling board causes a strong resonance due to two possibilities. First, the resonance of building elements has the same frequency, or almost the same, with a propagating sound frequency; second, the sound source has a low frequency and has powerful vibrations resulting in resonance occurring. A sound resonance is happening above the ceiling, which accidentally helps strengthen low frequencies (e.g., speaker box), thus forming the character and bringing out gamelan's spirit (soul).

It was stated above that to give rise to the spirit (soul) *karawitan*, because of the low frequency which is always continuous. Therefore, sound reflections caused by the ceiling, making low frequencies tend to last longer disappearance. Meanwhile, at high frequencies tends to disappear quickly. The effect quickly disappears sounds at high frequencies due to the absorbency of hair and audience attire. As discussed above gamelan has a frequency range of 40 Hz up to 2360 Hz, as well as the sound of the instrument when played tends to be in the frequency range of 40 Hz up to with 750 Hz, accidentally on the frequency this is the connecting tone framing the *gending* presentation to *karawitan* music (Trisnowati, 2017). Due to the horizontal movement of sound, then at low frequencies it is almost invisible (rise and fall due to free air movement), but because the vertical movement of sound exists the process of amplifying and reflecting sound on low frequency, then the musical presentation feels unified. This is actually what space can do better presenting the spirit (soul) of musical instruments without it amplification assistance.

Based on the function of the musical instrument presumably the dish requires space show. Musical music performance space with Javanese gamelan in general at this time not must be in a special room. Although until now society has a cult that gamelan will do magical powers and musical spirit (soul) appear. This matter it is proven that the gamelan performance space can adapt to the performance auditorium. In this is what a performance auditorium must have characteristics and room acoustics must at least fit the open space. Listen to the sound musical music in an open space, you will feel it very delicious because of the sounds it produces by softer instruments heard to the senses hearing.

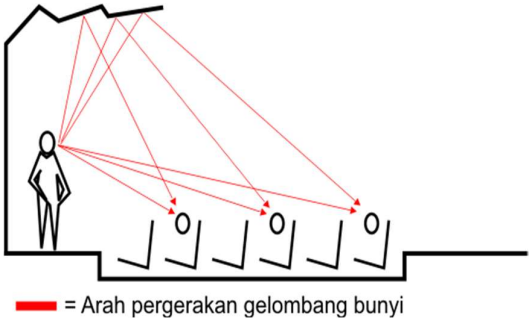

Figure 2. The open stage was developed with the addition of a back wall and roof for the distribution and repetition of sound

The open stage is shown in Fig. 2 in top, sound propagation is supported by the background wall as a reflector. Reflections visible in the image is the result of adding a wall at the back stage and the addition of a roof above the stage by Greek people. The process of sound reflection or reflection the sound helps strengthen and spreading the sound of a musical instrument or vocal throughout appreciator. That way, appreciators can to hear the sound source from the stage without the help of a sound system. Presumably, that space used for performing or sounding gamelan instruments in open spaces will be beneficial representative. Therefore, several instruments when played, gamelan requires spatial properties an echo that functions to reflect and express the source of the sound (specifically the frequency low as a frame). Another thing because sound propagation factors in open spaces, so makes the overall sound of the instrument felt merges.

5. CONCLUSION

The development of musical music with gamelan has not only occurred in Indonesia. Several countries worldwide have musical instruments, such as gamelans, and some countries have even held the International Gamelan Festival (IGF). West Java society uses melodic music other than to fill traditional ceremonies; it is also used as entertainment. Musical music This acts as a relationship or artistic service, as the *karawitan* appears to support or serve the needs of other performing arts, such as dance, theatre, and *wayang*, and recently, films also often use gamelan instruments for scoring the film according to the theme will be it was broadcast. Based on the music function *karawitan*, the performance requires an open performance space. Playing music in the musical hall with a gamelan usually only takes a little room. It proves that space gamelan performances can adapt to performance auditoriums. In this case, the show's building must have at least open equipment gamelan or room acoustics that suit a set of *gamelan*. It is more than just a gamelan; it has a deep performance space. The presentation needs the help of a technological process amplification if we look at culture and other music. Some examples of musical performances in different cultures are symphonic orchestra music with concert hall performance space or Kebyar gamelan from Bali, which was performed at *Wantilan.* The performance spaces have a level of intimacy between music, space, and pubs.

6. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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