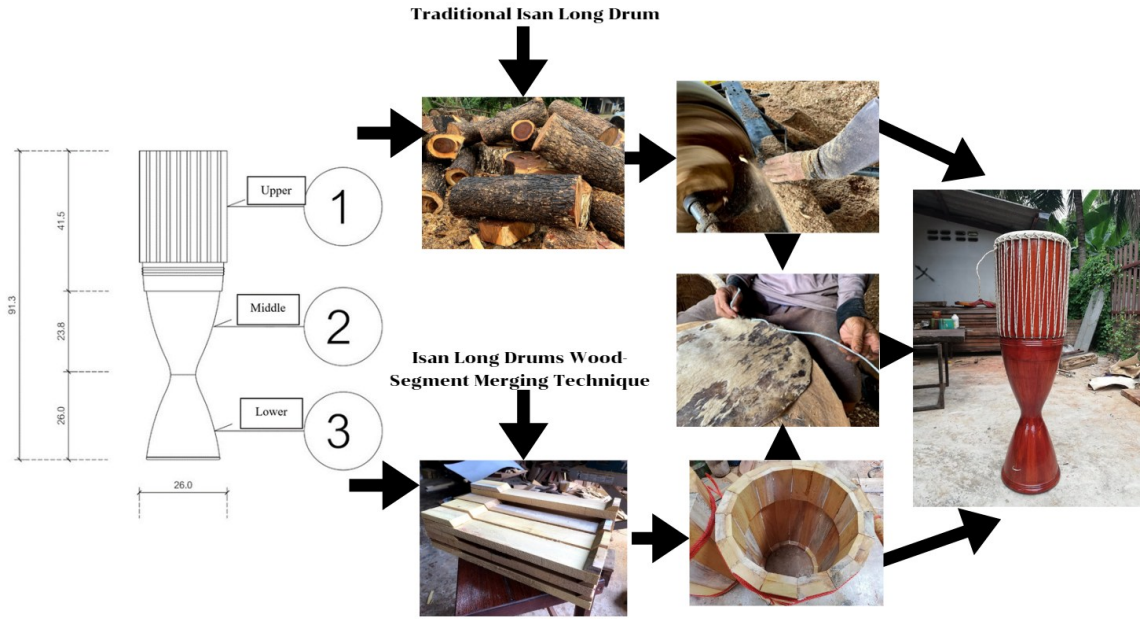
Crafting Isan Long Drums through the Wood-Segment Merging Technique

Sayam Chuangprakhon [a], Weerayut Seekhunlio [a,*], Warakorn Seeyo [a], Piyapun Santaveesuk [a], and Qin Chen [b]

* *Corresponding author: weerayut.s@msu.ac.th*

DOI: 10.15376/biores.21.2.4029-4044

GRAPHICAL ABSTRACT



Crafting Isan Long Drums through the Wood-Segment Merging Technique

Sayam Chuangprakhon [a], Weerayut Seekhunlio [a,*], Warakorn Seeyo [a], Piyapun Santaveesuk [a], and Qin Chen [b]

This study presents the development of a sustainable alternative method for crafting traditional Isan long drums through a wood-segment merging technique. Using a combination of documentary analysis, field research, and applied experimentation in collaboration with master drum-makers in Mahasarakham and Buriram provinces, the process was carried out in three phases: (1) analysis and design, (2) prototype production, and (3) refinement and final assembly. The revised design divided the drum into three segments—upper, middle, and lower—to improve material efficiency, ease of fabrication, and structural stability. Each segment was constructed from precisely cut, processed wood wedges, glued, shaped on a lathe, and seamlessly joined. The drumhead was prepared following traditional Isan methods, and the finished instrument was tested for tonal quality, showing results comparable to single-log drums. A panel of seven experts evaluated the drum on sound quality, aesthetics, durability, and suitability, with findings indicating equal or superior performance in most aspects compared to traditional methods. The results suggest that the wood-segment merging technique not only preserves the cultural authenticity and acoustic characteristics of the Isan long drum but also offers an environmentally sustainable and resource-efficient production method.

DOI: 10.15376/biores.21.2.4029-4044

Keywords: Isan long drum; Wood-segment merging technique; Sustainable craftsmanship; Thai folk musical instrument; Acoustic quality; Thailand; Folk music preservation

*Contact information: a: College of Music, Mahasarakham University, Mahasarakham 44150, Thailand; b: Chongqing Vocational College of Culture and Arts, Chongqing 401320, China; *Corresponding author: weerayut.s@msu.ac.th*

INTRODUCTION

The Isan long drum is an ancient percussion instrument that produces music by striking a stretched animal leather drumhead. Archaeological evidence reaching back to the 3rd to 6th centuries demonstrates its historical use in ceremonial contexts as part of Southeast Asia's cultural legacy. These drums were first standard in Northern Vietnam and date back to the Dong Son culture, which was noted for its bronze drum artistry. Numerous drums, including bronze drums known as "Dong Son drums," have been unearthed in various sizes, indicating that ancient cultures produced and continued to use them (Chuthawichit *et al.* 2014).

The exact origins of the traditional Isan long drum are unknown, but it has become vital to local cultural and ceremonial rituals, frequently performed in ensembles to enhance festivals. The instrument, known locally as "Glong Kon Loong" or "Glong Haang" (bottomless drum or tailed drum), consists of a single drumhead fastened by ropes. The

body is generally made of huge logs such as jackfruit, chamcha, mango, or other appropriate woods (Liu *et al.* 2025). The wood is fashioned by turning or carving, hollowed in the center, and tapered from a wider front end to a narrower tail (Phimprajun *et al.* 2022; Inchan 2021). A combination of cooked sticky rice and ashes is put on the drumhead to improve the sound quality.

In Isan communities, the long drum is prominently featured in processions marking local ceremonies, including religious festivals, ordinations, and merit-making activities such as Bun Phawet (Month 4), Songkran celebrations, Bun Bang Fai (Month 6), candle processions during Buddhist Lent (Month 8), and other creative events. A long drum ensemble requires a variety of components, including experienced performers, dancers, competent artisans, trained trainers, appropriate practice locations, and auxiliary instruments such as ramana drums, cymbals, ching, phin, bass, and keyboards (Choatchamrat and Moonsuwan 2022).

The traditional Isan long drum has an extended cylindrical shape with a big, rounded head tapering toward the tail, similar to a giant clay mortar with an open, trumpet-shaped end (Detkawinlerd 2025). Traditional resources, such as jackfruit wood, have become increasingly rare, forcing craftspeople to use substitutes such as chamcha or mango wood (Kumnin *et al.* 2023; Erofeev *et al.* 2025). These solutions generate equivalent sound quality but are insufficient owing to the ongoing high demand and difficulties in maintenance (Petsaen and Nesusin 2021).

Given these challenges, the researchers have been experimenting with a novel technology called wood-segment merging, which utilizes widely accessible woods such as pine and rubberwood, as well as reused boards from woodworking. This approach aims to alleviate the scarcity of large logs, reduce costs and manufacturing time, and enhance sustainability. By combining smaller wood pieces with contemporary equipment and procedures, this technology enhances resource efficiency, maintains giant trees, and contributes favorably to environmental conservation.

General Knowledge about Traditional Long Drums

According to Champadaeng (2018) and Kritwittaya (2020), the "Klong Yao," or long drum, normally consists of a single drumhead and an extended body ornamented with colorful cloth and tightening ropes. Pricha Pinthong focused on two separate types: the bigger northern "Klong Aew," which is used for elaborate processions and religious dances, and a smaller form inherited from Burmese traditions that is generally popular in festive events. Phatthaphong (2017) also emphasized its Burmese origins, implying that it was introduced during historical wars or cultural exchanges during King Rama IV's reign.

Additionally, Karin (2019) acknowledged uncertainty about the drum's actual origins, although both noted a strong Burmese influence, likely originating from the Shan (Thai Yai) people. They added that the long drum, originally popular in northern Thailand, became widely used across the country, particularly in ordination parades, festival celebrations, and cultural processions (Khan *et al.* 2004). Sangaroon *et al.* (2022) provided additional context, placing the long drum within a broader historical tradition of using percussion instruments for community communication and signaling, which evolved from primitive wooden percussion and animal horns to bronze drums discovered in prehistoric and Dvaravati archaeological sites (Lu *et al.* 2022; Liu *et al.* 2024). This narrative emphasizes that the Isan long drum is a complex historical amalgamation that incorporates cultural influences from Mon, Burmese, Shan, and Thai traditions, evolving from a

communication and ritual instrument to a valued component of contemporary cultural expression and identity.

Traditional Isan Long Drum-Making Process

The researchers conducted fieldwork to learn about the traditional method of making Isan long drums from solid wood. This procedure, which is still used today, consists of multiple specific phases. First, locally obtained woods, such as jackfruit, mango, or rain tree, are selected and chopped into logs measuring 37" to 43" (94 to 109 cm) in length and 10" to 13" (25.4 to 33 cm) in diameter (Fig. 1a). Before mounting on a lathe, the wood's exterior surface is coarsely shaped with an axe. To attach the wood to the lathe machine, oval holes are bored into both ends of the log (Denaud *et al.* 2007; Zarins *et al.* 2012). Custom-made carving tools, such as sharp lathe knives, are used to shape the drum body, create grooves for metal rings, curve the drum's waist, and engrave beautiful patterns (Fig. 1b). Once the drum's shape is finished, the head and tail are trimmed. The inside is hollowed out to a thickness of roughly 1.0" (2.54 cm) using a drill press (Fig. 1c). The drum is then enhanced by applying a combination of sawdust and glue to smooth and seal any cracks or holes. Grooves for threading the drumhead rope are cut evenly, about an inch apart, for a total of 29 holes and the drum is left to cure in the shade for one to two weeks.

Fig. 1a. Wood used to make the traditional Isan long drum

Fig. 1b. The lathe machines

Fig. 1c. Drilling wood

Fig. 1d. Hole for the rope

After drying, the drum is sanded with sandpaper while mounted on the lathe, then coated with lacquer and urethane to achieve a polished appearance (Fig. 2a). The drumhead-making process begins with the selection of high-quality cowhide, preferably from a female cow older than two years. The hide is sun-dried, softened with water for 12 hours, dehaired, and battered for flexibility. The drumhead is cut to form, marked, and perforated to match the drum's groove holes. Threading the drumhead involves three rounds of nylon rope wound in a specific order (Fig. 2b). A second round of threading, the tensioning rope, is completed while the hide is still moist to guarantee correct tightening as it dries. Once fixed, set the drum in the sun to dry, hair side facing outward (Fig. 2c). After drying, the hide is properly scraped and sanded to retain a constant thickness. Finally, the tensioning rope is tightened one more time to achieve ideal drumhead tension and sound quality, bringing the Isan drum-making process to a close (Fig. 2d).

Fig. 2a. The Isan long drum has been turned and coated with urethane

Fig. 2b. Threading the drum

Fig. 2c. Drumheads installed

Fig. 2d. Isan long drum

EXPERIMENTAL

This research aimed to develop an alternative method for constructing traditional Isan long drums using a wood-segment merging technique. The motivation for this study arose from the increasing scarcity of large-diameter timber logs traditionally used to carve drum bodies (Homhuan and Sensai 2024). The researchers employed a combination of

documentary analysis, field research, and applied experimentation in collaboration with master drum-makers in Mahasarakham and Buriram provinces in Thailand. The study was conducted in three main phases: (1) analysis and design, (2) prototype production and evaluation, and (3) refinement and final construction.

Phase 1: Analysis and Design

In the first phase, the researchers analyzed the structure and components of long drums made from solid logs, using a prototype drum from Ban Talat, Ban Wai Subdistrict, Wapi Pathum District, Mahasarakham as a reference. The prototype was brought to experienced artisans in Nong Ki District, Buriram Province, to assess feasibility and inform the design process. The characteristics of the drum were examined in detail, including dimensions, contours, and assembly techniques (Fig. 3a).

Subsequently, the researchers created a digital model of the drum using computer-aided design (CAD) software (Rao and Jasthi 2000; Erozan and Ozan 2020). The initial design divided the drum into two main components: the upper part (A), which holds the drumhead, and the lower part (B), forming the tail (Fig. 3b). However, during the practical trial, it was discovered that constructing the drum in only two segments was inefficient in terms of material usage and difficult to fabricate, especially when precise angular cuts were required for joining (Seekhunlio *et al.* 2024). This prompted a revision of the design to improve practicality and structural strength.

Fig. 3a. Measurements

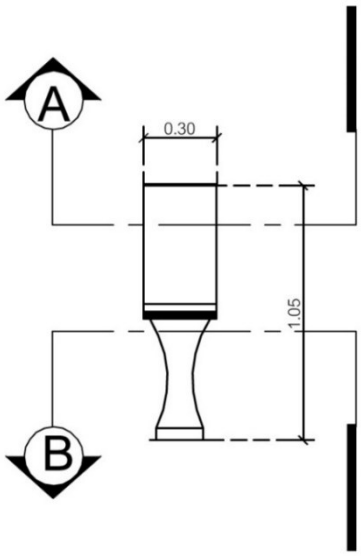


Fig. 3b. Structure pattern

Phase 2: Prototype Construction and Evaluation

In response to the initial difficulties, the researchers revised the model by dividing the drum into three separate segments—the upper (Section 1), middle (Section 2), and lower (Section 3)—to facilitate the merging process and improve overall drum stability. The new design was modeled using CAD to illustrate all proportional relationships and construction parameters (Fig. 4).

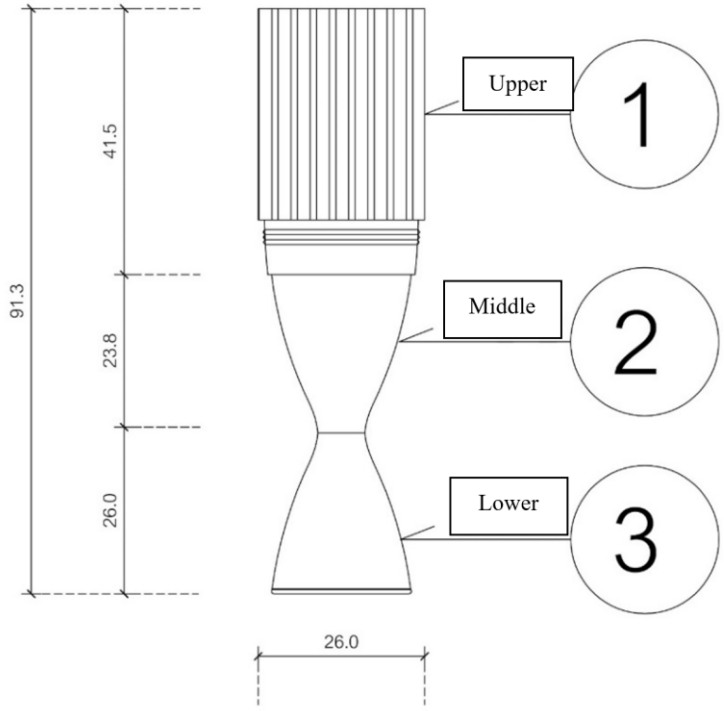


Fig. 4. The drum components are divided into three parts and the unit used for each measurement is "cm"

Section 1 (*Upper part*)

This is the most critical segment, as it supports the drumhead. It was constructed using three different sizes of processed wood, with 16 pieces of each size (Fig. 5a):

- 41.5 cm (L) × 5.2 cm (W) × 2 cm (T)
- 10 cm (L) × 5.2 cm (W) × 2 cm (T)
- 2.5 cm (L) × 5.2 cm (W) × 2 cm (T)

The wood pieces were first glued together with latex adhesive and dried for two days. Next, each segment was cut along its length to an angle of 14º on both sides to form a complete circle when joined (Fig. 5b). After reapplying glue, the segments were reassembled and secured with nylon rope, then left to dry for another two days (Fig. 5c).

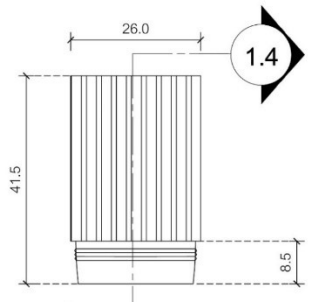


Fig. 5a. Upper part of drum

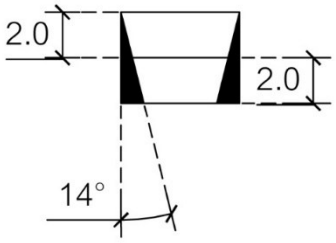


Fig. 5b. Wood angle of 14º

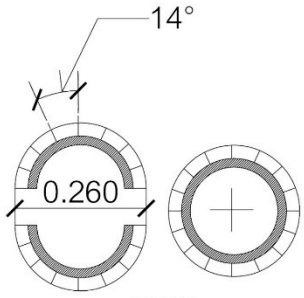


Fig. 5c. Joining wood together

Note: All measurements are in unit "cm".

Section 2 (Middle part)

This part connects the top and bottom of the drum. It used 8 rectangular blocks of dimensions 28.5 cm × 7.5 cm × 3 cm, which were each split diagonally to form 16 wedge-shaped pieces with a top width of 5.2 cm and a bottom width of 2 cm (Figs. 6a and 6b). These were also angled to 14º, glued, and bound into a circular form, as with the top section (Fig. 6c).

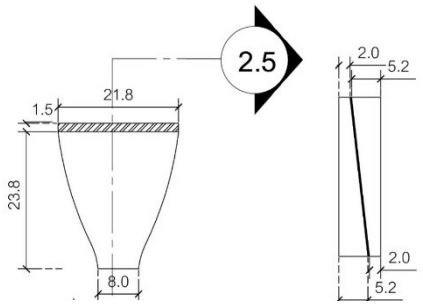


Fig. 6a. Middle of the drum

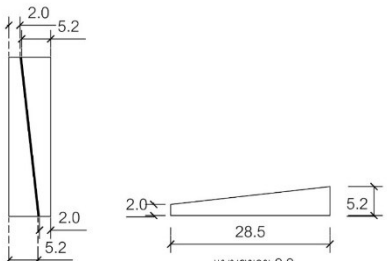


Fig. 6b. Saw the two pieces

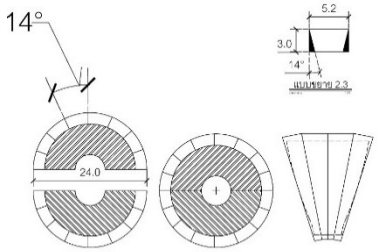


Fig. 6c. Joining wood 14º

Note: All measurements are in unit "cm".

Section 3 (Lower part)

Serving as the base, this section uses 8 blocks of 30.5 cm × 7.5 cm × 3 cm, each divided into 2 wedges. Each wedge was 30.5 cm long, with a top width of 1.8 cm and a bottom width of 5.2 cm. These were also angled at 14º and glued together to form the flaring tail of the drum (Fig. 7a). After the three sections were completed, they were mounted on a lathe and shaped externally to achieve the smooth curves and proportions of a traditional Isan long drum (Fig. 7b). Tenon joints were carved to allow the segments to be assembled securely.

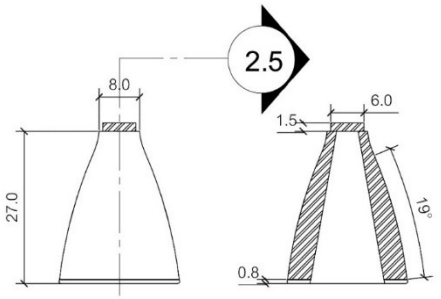


Fig. 7a. Lower part of the drum

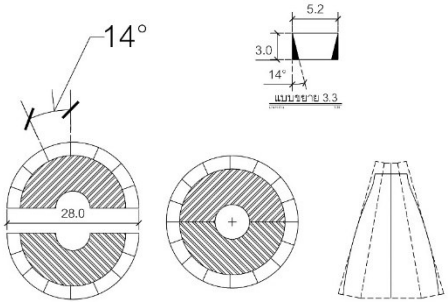


Fig. 7c. Joining wood tenon

Note: All measurements are in unit "cm".

Phase 3: Refinement and Final Assembly

After successful shaping, the assembled drum was subjected to traditional finishing methods. The drumhead preparation followed the same traditional process used by Isan drum-makers, as detailed in the traditional Isan long drum-making process.

RESULTS AND DISCUSSION

The researchers developed and refined a new method for crafting the traditional Isan long drum by applying a wood-segment merging technique. This method was proposed as a sustainable alternative to the conventional practice of carving the drum body from large-diameter logs, which have become increasingly scarce. By using smaller, processed wood pieces, the technique aimed to preserve the drum's traditional form, tonal quality, and structural durability while promoting efficient use of timber resources (Fig. 8). Previously, the researchers collaborated on prototype trials with two craftsmen specializing in musical instrument making and a musician who plays the Isan long drum. Through this collaboration, they made adjustments to improve the practicality and craftsmanship of the design. The drum structure was divided into three main sections—upper, middle, and lower—with all measurements recorded in centimeters.

Fig. 8. Process wood to the required size according to the model

The upper section, which is the most critical part of the drum as it holds and secures the drumhead, was constructed from three different sizes of processed wood: 41.5 × 5.2 × 2 cm, 10 × 5.2 × 2 cm, and 2.5 × 5.2 × 2 cm, each size cut into sixteen identical pieces. These were glued with latex adhesive and left to dry for approximately two days to ensure complete curing (Figs. 9a and 9b).

Fig. 9a. Apply glue to the wood

Fig. 9b. After the glue has been applied

After drying, each of the sixteen assembled units was cut to a 14º on both edges to allow them to be joined into a perfect circular frame, using a custom-built angle jig to secure the pieces during cutting with a circular saw (Fig. 10a). Once the beveling was complete, the pieces were glued again, assembled into a circular form, bound tightly with nylon rope, and left to dry for another two days to form the complete upper section (Fig. 10b).

Fig. 10a. Model for the holding angle upper section

Fig. 10b. Glue all 16 pieces of wood together.

The middle section, which serves as a connector between the upper and lower sections, was made by first preparing eight wood blocks measuring 28.5 × 7.5 × 3 cm. Each block was then split into two tapered wedges measuring 28.5 cm in length, 5.2 cm wide at the top, and 2 cm wide at the bottom, resulting in a total of sixteen pieces (Fig. 11).

Fig. 11. Process the middle section of wood into 8 pieces

These wedges were cut to a 14º angle on both long edges using the same jig and saw arrangement (Fig. 12a). The sixteen wedges were first glued into pairs (Fig. 12b) and dried for two days, then assembled into a full circle, glued, bound with nylon rope, and dried for another two days (Fig. 12c).

Fig. 12a. Model for the holding angle middle section

Fig. 12b. Glue the wood together into 8 pairs

Fig. 12c. Glue the wood together and tie it with rope for about 2 days

Fig. 13a. Model for the holding angle lower section

Fig. 13b. Saw the wood into at 14º

The lower section of the drum, serving as the base for structural stability and resonance, was crafted with dimensions tailored to its flared profile. Eight rectangular wood blocks, each measuring 30.5 × 7.5 × 3 cm, were split into two tapered wedges per block, yielding sixteen pieces measuring 30.5 cm in length, 1.8 cm wide at the top, and 5.2

cm wide at the bottom (Fig. 13a). Both long edges of each wedge were cut at a 14º bevel using a custom jig and circular saw (Fig. 13b).

The wedges were paired, glued with latex adhesive and dried for two days before being joined into a complete circular base (Fig. 14). The assembly was bound with nylon rope for uniform pressure and left to cure for another two days, producing a sturdy lower section ready for final shaping and integration with the rest of the drum.

Fig. 14. Glue and glue the wood together in pairs, a total of eight pairs

With the completion of all three sections—the upper, middle, and lower—the construction progressed to the external shaping stage, a crucial process for achieving the smooth contours and aesthetic form characteristic of a traditional Isan long drum. Each section was mounted individually on a lathe, with a stabilizing rod inserted through the interior to prevent any deformation or warping during the turning process (Fig. 15a). The outer surfaces were carefully shaped, following the pre-determined curvature of the drum body, to create a balanced and visually appealing profile (Fig. 15b).

Fig. 15a. Use a stick to support the drum

Fig. 15b. Turning wood to shape the drum

Once the individual sections had been shaped, they were precisely aligned and joined together using latex adhesive to ensure a strong bond. The fully assembled drum body was then remounted on the lathe, allowing the craftsman to blend the joints between the sections seamlessly (Fig. 16a). This joint-blending process ensured that the transitions were imperceptible to both the eye and the touch, resulting in a unified, continuous form. The shaping stage not only refined the instrument's visual elegance but also contributed to its acoustic performance by creating a consistent, uninterrupted resonance chamber throughout the drum body. Then the sections were joined together and returned to the lathe for joint blending, ensuring that the transitions between parts were seamless (Fig. 16b).

Fig. 16a. All three drum parts have been machined

Fig. 16b. Assemble the three drum pieces

The drum-head preparation adhered to the same traditional methods employed by Isan drum-makers, as outlined in the conventional Isan long drum-making process. The completed wood-segment Isan long drum (Fig. 17a) was then tested for tonal quality. The sound produced was found to be almost identical to that of a traditional single-log drum, indicating that the wood-segment merging technique successfully preserved the instrument's acoustic properties while providing a practical and environmentally

sustainable manufacturing method (Fig. 17b). This method not only maintains the cultural authenticity of the Isan long drum but also addresses material shortages by enabling the use of smaller, more readily available timber pieces, thus offering a viable alternative to traditional log-based production.

Fig. 17a. The finished Isan long drums through the wood-segment merging technique

Fig. 17b. QR code linking to the sound test video of Isan long drums constructed using the wood-segment merging technique

The researcher presented the Isan long drum produced using the wood-segment merging technique to a group of experts for quality assessment. The evaluation process involved seven individuals, including three lecturers in Isan folk music, two leaders of traditional Isan long drum ensembles, and two traditional Isan long drum craftsmen.

The evaluation covered four aspects: Sound quality, aesthetic appearance, durability, and suitability. The scoring criteria were as follows:

5 = Single-piece wood is better
4 = Wood-segment merging is better
3 = No difference
2 = Single-piece wood is slightly better
1 = Wood-segment merging is slightly better

Table 1. The Results of the Evaluation

Evaluation Item	Frequency (Rating)				
	5	4	3	2	1
Sound quality	2	2	3	0	0
Aesthetic appearance	3	3	0	1	0
Durability	1	4	2	0	0
Suitability	3	4	0	0	0
Total	9	13	5	1	0

From Table 1, the evaluation results show that for sound quality, two experts rated single-piece wood as better, two preferred the wood-segment merging technique, and three found no difference. For aesthetic appearance, three preferred single-piece wood, three preferred wood-segment merging, and one slightly preferred single-piece wood. For durability, one rated single-piece wood as better, four preferred wood-segment merging, and two found no difference. For suitability, three favored single-piece wood, while four preferred wood-segment merging. Overall, the findings indicate that the wood-segment merging technique is generally preferred over single-piece wood.

Additional recommendations is that the drum should be tested in real performance settings with musician groups or long drum ensembles two to three times to assess durability and standardized sound quality. It is also recommended to improve tools and equipment to minimize production costs and to develop a process for faster wood shaping.

CONCLUSIONS

1. This study aimed to develop an alternative method for crafting traditional Isan long drums using a wood-segment merging technique. The approach was designed to address the issue of scarce large-diameter logs while preserving the drum's traditional form, tonal quality, and durability.
2. The technique makes use of smaller, processed wood pieces rather than a single large log. This enables more efficient use of timber resources, reduces waste, and provides an environmentally friendly alternative that meets cultural authenticity standards.
3. The study was conducted in three phases: analysis and design, prototype construction, and refinement. The design evolved from a two-section to a three-section structure—upper, middle, and lower parts—for easier fabrication, stronger joints, and improved stability.
4. Each section was made from precisely cut wood wedges, glued, bound, and dried before being shaped on a lathe. The sections were then seamlessly joined, the drumhead was prepared using traditional methods, and the finished drum was tested for sound quality against a traditional single-log drum.

5. Seven experts evaluated the drum based on sound quality, aesthetics, durability, and suitability. The results showed similar sound quality to single-piece drums, better durability, and higher suitability ratings. While opinions on aesthetics were mixed, the overall preference leaned toward the wood-segment merging technique for its practicality and sustainability.

REFERENCES CITED

Champadaeng, S. (2018). "Long drum in the cultural traditions of the people of Wapipathum District, Maha Sarakham Province," *Journal of Fine and Applied Arts Khon Kaen University* 10(1), 91-109.

Choatchamrat, S., and Moonsuwan, T. (2022). "Conveying the display styles and the judging criteria for the Isan Klong Yaw (long drum) contest," *Linguistics and Culture Review* 6, 240-257. https://doi.org/10.21744/lingcure.v6ns5.2071

Chuthawichit, Y., Yodmalee, B., and Poklin, S. (2014). "The conservation and development of Isan long-drum performances to promote local culture," *Asian Culture and History* 6(2), 191-201. https://doi.org/10.5539/ach.v6n2p191

Denaud, L. É., Bléron, L., Ratle, A., and Marchal, R. (2007). "Online control of wood peeling process: Acoustical and vibratory measurements of lathe checks frequency," *Annals of Forest Science* 64(5), 569-575. https://doi.org/10.1051/forest:2007034

Detkawinlerd, W. (2025). "Development and promotion of the art of Isan long drums," *Journal of Social Science for Local Development Rajabhat Maha Sarakham University* 9(1), 322-334.

Erofeev, V., Stepina, I., Badamshin, R., Afonin, V., Smirnov, V., Samchenko, S., and Kozlova, I. (2025). "Effect of wood fillers on strength and biodegradation of caustic magnesite," *BioResources* 20(3), 5790-5800. https://doi.org/10.15376/biores.20.3.5790-5800

Erozan, Ç., and Ozan, O. (2020). "Evaluation of the precision of different intraoral scanner-computer aided design (CAD) software combinations in digital dentistry," *Medical Science Monitor: International Medical Journal of Experimental and Clinical Research* 26, e918529. https://doi.org/10.12659/MSM.918529

Homhuan, W., and Sensai, P. (2024). "The significance of percussion instruments in Isan Thai folk music within the context of music education and learning," *Journal of Education and Learning* 13(1), 180-189. https://doi.org/10.5539/jel.v13n1p180

Inchan, W. (2021). "The rhythm of the Isan long drum band, Seing, for creative use in drumlines," *Journal of Social Science for Local Development Rajabhat Maha Sarakham University* 5(1), 263-269.

Karin, K. (2019). "Development of the performance style of the long drum ensemble in Maha Sarakham Province," *Journal of Humanities and Social Sciences, Ubon Ratchathani University* 10(1), 253–273.

Khan, Z. S., Tokaruk, W. A., and Morris, S. W. (2004). "Oscillatory granular segregation in a long drum mixer," *Europhysics Letters (EPL)* 66(2), 212-218. https://doi.org/10.1209/epl/i2003-10157-4

Kritwittaya, B. (2020). "Thai long drum ensemble, Ban Thet Thai, Chiang Rai Province," *Mahidol Music Journal* 3(1), 60-73.

Kumnin, W., Rachjun, P., and Thiangnga, S. (2023). "Conservation guidelines for long drums of Jum Chang Village, Umma Sub-District, Phon Thong District, Roi Et

Province," *Journal of Academic Research and Innovation in Social Science Review* 3(1), 46-69.

Liu, J., Nicolas, A., and Seekhunlio, W. (2024). "Preservation and transmission of cultural knowledge about bronze drums in Donglan County, Guangxi, China," *International Education Studies* 17(4), 32-41. https://doi.org/10.5539/ies.v17n4p32

Liu, M., Yang, Y., Liu, Y., and Yao, L. (2025). "Precise improvement of wood properties by solution quantitative adsorption furfurylation based on cell wall modification," *BioResources* 20(3), 5487-5500. https://doi.org/10.15376/biores.20.3.5487-5500

Lu, Q., Li, Y., Zou, G., and Gong, S. (2022). "Separation or integration? Further insights from a study on chemical datasets of ancient bronze drums from South and Southeast Guangxi, China," *Heritage Science* 10(1), article 106. https://doi.org/10.1186/s40494-022-00808-0

Petsaen, J., and Nesusin, S. (2021). "Improving the sound quality of Isan long drums," *Mekong-Salween Civilization Studies Journal* 12(1), 70-91.

Phatthaphong, P. (2017). "A study of the long drum in the society and culture of Nakhon Sawan people," *The Golden Teak: Humanity and Social Science Journal* 23(2), 14-27.

Phimprajun, R., Pengsri, T., Choatchamrat, S., and Chuangprakhon, S. (2022). "Guidelines for the development of Silp-Isan Klong Yao band performance style," *Journal of Educational Issues* 8(2), 278-287. DOI: 10.5296/jei.v8i2.20116

Rao, P., and Jasthi, S. (2000). "Computer-aided process planning (CAPP) in manufacturing systems and their implementation," in: *Computer-Aided Design, Engineering, and Manufacturing*. https://doi.org/10.1201/9781420049978-c5

Sangaroon, J., Pikulsri, C., and Nesusin, S. (2022). "Adaptation of Tai Yai music culture in Northern Thailand," *Rangsit Music Journal* 17(2), 30-44.

Seekhunlio, W., Chuangprakhon, S., and Phiwphuy, K. (2024). "The preservation of Isan folk music with digital sound technology," *Multidisciplinary Science Journal* 6(4), 2024058. https://doi.org/10.31893/multiscience.2024058

Zarins, M., Torims, T., Bumanis, M., and Chamans, A. (2012). "Diagnostics of drum type wood chipping machines," *Applied Mechanics and Materials* 220–223, 775-780. DOI: 10.4028/www.scientific.net/amm.220-223.775

Article submitted: August 13, 2025; Peer review completed: September 18, 2025;
Revised version received: March 6, 2026; Published: March 20, 2026.
DOI: 10.15376/biores.21.2.4029-4044