The Skateboard Embaire: Reanimating tradition through musical instrument design

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Figure 1: The Skateboard Embaire being played

Abstract

Digital musical instruments (DMIs) have a high degree of flexibility of form, sound and materials, and a unique ability to create cultural continuity between traditional and contemporary musical practice. In this paper we demonstrate this concept through the process of design and construction of an embaire created during a residency at a music festival in Nairobi Kenya in 2025. The embaire, a traditional Ugandan xylophone, is typically large in scale, accommodates multiple players, and uses a ground hole for resonance. Here we reimagined it in a modern context using discarded skateboard decks sourced from the local skateboard community and a custom-built sensing and sound synthesis system. Building on historical tuning research from 1940s musicological field notes and re-implementing this tuning system in Pure Data, this playable hardware implementation strongly links traditional African musical heritage with contemporary culture and digital technology. This project offers a model for sustainable instrument design that respects traditional practices while embracing local resources and modern sensing technologies.

Keywords

instrument design, hardware, cultural continuity

1 Introduction and context

The embaire is a traditional xylophone of the Basoga people in Uganda. However, like many traditional instruments, the embaire faces contemporary pressures: geographic displacement, generational discontinuity, and hegemonic Western cultural dominance. Its survival depends not on preservation in fixed form, but on evolution by finding new contexts and practitioners.

This paper presents a case study in such evolution: a contemporary embaire redesigned during a residency at the Kilele festival in 2025 in Nairobi, Kenya. This project emerged from a three-way

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Figure 2: Historical picture of an embaire [11]

collaboration between three musician/artist-technologists, building on previous research on historical embaire tuning, gleaned from 1940s musicological sources. The tuning was implemented in a Pure Data patch, and during this collaboration we built a hardware version using salvaged skateboard decks and a custom-designed multichannel sensing network. The result maintains the embaire's traditional tuning and playability while its materiality exists in a radically different material and technological form, with digital techniques enabling new sonic and performative possibilities.

This paper demonstrates the ways in which this project exemplifies *cultural continuity*, by maintaining essential cultural identity while enabling adaptive evolution through new materials, technologies, and contexts. The embaire persists not because its material remains unchanged, but because what it does culturally and musically persists. We ground this in ethnomusicological theory, postcolonial hybridity, and NIME scholarship on sustainable design and cultural probes. Methodologically, reconstructing embaire tuning from archival sources represents a decolonial, re-indigenising practice, asserting the embaire's right to contemporary technological expression on its own terms.

2 Background and Context

2.1 The Embaire's Cultural Significance

The embaire has its origins in the Busoga Kingdom of southeast Uganda. It is a musical instrument with specific ceremonial and social functions, played at celebrations and gatherings such as weddings, funerals and graduations. The embaire is large and communal, and played by multiple players positioned on both sides. Its lamellas, up to 20 in number, are loosely held in place with pegs (often banana stems), and richly decorated.

A traditional embaire is positioned over a hole dug in the ground which it uses as a resonator. The lowest-sounding lamellas can be pressed with the hands to alter their pitch, and drums are sometimes used as an extension of the lower registers.

The embaire continues to be played in both traditional and contemporary contexts, exemplified by the Nakibembe Xylophone Troupe on the experimental African record label Nyege Nyege Tapes [1], who perform both historical and contemporary iterations. Despite this, the embaire faces contemporary pressures similar to many traditional instruments, such as generational discontinuity through the dominance of Western popular music. Its continued vitality and longevity depends on its ability to transcend historical stasis and integrate into modern creative practices.

2.2 Tuning Systems and Construction

The embaire's ceremonial functions depend on the embaire's distinctive tuning and construction. The embaire employs a pentatonic tuning system with intervals that approximate equidistance within each octave, typically yielding 5 notes per 1200 cents (rather than Western 12-TET divisions). Measurements from specific instruments reveal modest deviations from pure equality, reflecting both tuning practice and material constraints.

For example, Teffera reports intervals clustering around 150-180 cents for a Busoga embaire [13], while the 1948 field notes we referenced in this project [15] yield pairwise intervals of 197-310 cents across the measured range. Micklem et al. describe the Nakibembe ensemble's tuning as similarly near-equidistant, optimized for polyrhythmic interplay [11].

The embaire typically uses a ground hole as a resonator. A hole is dug and lined with banana leaves, and the instrument placed over it to provide amplification. The wood of the lamellas tends to vary by region, but generally wood of the mukeremba or lusambya trees is used. The lamellas are tuned through adjustment of forms, such as whittling away at the wood.[8]. Though the form of the embaire has undergone some evolution in the 1970s, for example expanding in size and materiality varying due to wood becoming unaffordable[13], its core form remains consistent.

2.3 Tradition as Dynamic Practice

Material specificities like mukeremba wood raise fundamental questions about what constitutes 'tradition'. Cultural theorists challenge fixed notions of cultural essence: Stuart Hall frames traditions as active 'positioning' that persists through transformation [4], while Paul Gilroy describes a 'changing same' maintained through adaptation [3]. Arjun Appadurai emphasizes objects' agency in generating meaning through material circulation [1], and Tim Ingold locates tradition in making practices rather than fixed forms [5]. These perspectives reposition tradition as participatory process, opening possibilities for contemporary reinterpretation, and we return to them in Section 5.4.

2.4 DMIs and Cultural Practice

DMIs afford high flexibility in form, sound, and materials, decoupling gesture from acoustics via digital mappings, sensors, and synthesis. This enables cultural reinterpretation: historical tunings reimplemented in software [9], traditional gestures driving contemporary synthesis, contemporary materials (e.g., recycled electronics) reconfigured into heritage forms [10].

Though this freedom is attractive, NIME has recently turned to considering how we imprint our values on what we produce as we negotiate between technical possibilities, materials, and cultural aesthetics [9]. NIME scholarship has also begun to critique

[1] https://nyegenyegetapes.bandcamp.com/album/nakibembe-embaire-group

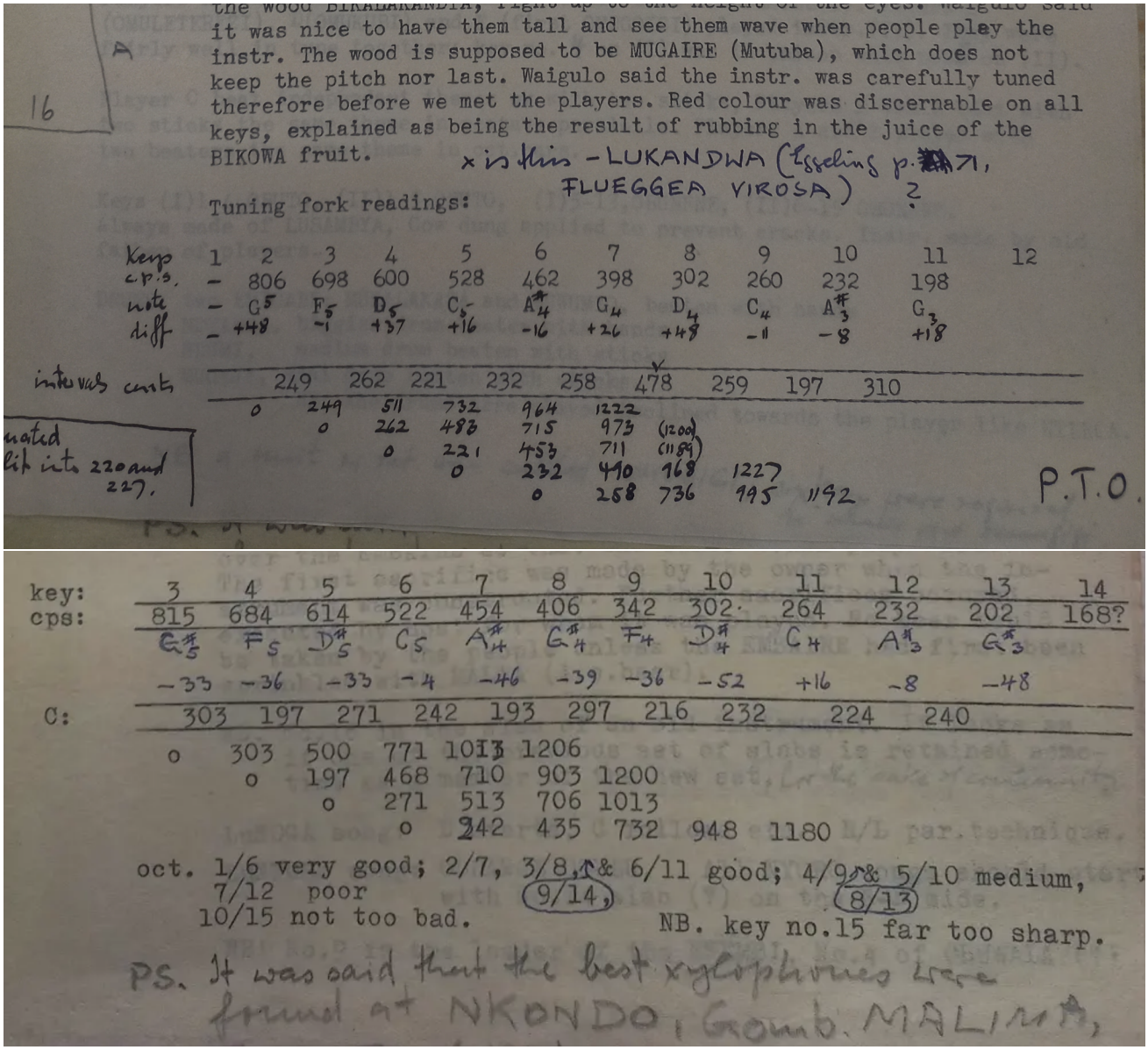

Figure 3: Screenshots of tuning fork measurements of the embaire.

its own bias towards technical factors: Jianing et al. note materiality's under-exploration versus sensors/mappings [7], and Xambó et al. lament DMIs' frequent lack of "finish, aesthetic consideration, and material quality" [17].

Sustainability is also an emerging theme, as NIME becomes increasingly aware of its social, political, and environmental impact [12]. Masu et al. advocate recycling, local production, and material longevity [10], addressing global inequities like East Africa's disproportionate climate burden [16]. These developments position DMIs as potential allies in cultural continuity, honoring inherited knowledge while reflecting contemporary constraints [17].

3 Previous research

In the first phase of this project that took place in 2024, Karugu and Huguenin-Virchaux did intensive investigation into the details of embaire tuning, with the goal of reproducing it in software with a high degree of fidelity. This process of recovering and reactivating forgotten archival data aligns with the methodology of media archaeology, treating the 1948 records not as static history, but as a functional site for contemporary excavation.

In that previous research they obtained photographs of field notes of unknown origin [15]. Dated September 1948, this document contains both typed and handwritten notes, and is a rich source of ad-hoc information about the embaire and its tuning. Clearly written by a trained observer, it reports tuning-fork measurements of each lamella of several embaires. Though we have no precise information on their methods, the notes explicitly state that these are tuning fork measurements, meaning that the observer likely brought tuning forks of reference values and estimated the frequency of a lamella by listening to the beat rate that occurs when the frequency of the lamella and the fork differ, and then estimating the lamella's frequency from that difference.

The most fascinating part of this document are the handwritten notations. In Figure 3 (top), the author has measured each lamella in Hz, and mapped each one to the nearest 12-TET note, computing the cents deviation. They then compute intervals in cents between keys and cumulative positions, presumably to see if there is any recognisable pattern.

In another instance (Figure 3, bottom) the author has noted the Hz measurement as well as the difference in pitch from the closest 12-TET note. In the row labelled 'C', they note numbers (303, 197, 271, and so on) that appear to be interval sizes in cents between selected key pairs (not a simple adjacent difference; they seem to be exploring multiple span combinations). Below that, the stacks of numbers (e.g. 0 / 303 / 500, etc.) appear to be cumulative sums of those cents values for different starting points or different interval chains, likely checking if any of those intervals add up to 1200 cents (a Western octave). There are further notes, stating "oct. 1/6 very good; 2/7, 3/8 & 6/11 good; 4/9 & 5/10 medium, 7/12 poor, 10/15 not too bad", which appear to rate how close various key-spans come to a 'standard' octave.

This document was extremely valuable for two reasons. Firstly, it is ad-hoc, personal documentation of a trained observer wrestling with how to understand embaire tuning using what were likely the only tools available to field work in 1948: standardised tuning forks and a well-trained ear. Secondly, these notes reveal the observer's assumptions; they interrogate the embaire's tuning through the lens of Western 12-TET, rather than documenting the system in its own right.

This set up the goals of the next phase of the project. We had historically important observational data on embaire tuning, but because it would be implemented in software, we did not need to carry over any Western assumptions about what the embaire tuning 'should' be, and could instead represent it on its own terms.

Figure 4: Top: Skateboard decks being placed on supporting structure.
Bottom: Mallets made out of discarded skateboard wheels.

4 Building the Skateboard Embaire

This project was carried out as part of the Instruments Makers Lab at the Kilele Summit in Nairobi, Kenya, in February 2025.

4.1 Construction

We began by discussing material configurations, and how to source from the local ecosystem as materials are not easy to get. The Instruments Makers Lab was located in central Nairobi, and the Skate Society of Kenya practices on its roof. We asked if they had any discarded boards, and they provided eight used skate decks. These boards represented both global and local skate brands, and were marked by heavy wear. We positioned them grip tape side down for natural downward curve and visible patina (see Figure 4, top).

We constructed a 2,5m support frame from scrap wood. Traditional embaires use pegs, often banana stems, between lamellas so they can freely vibrate but will stay in place. We replicated this by using nails wrapped in foam dishcloths sourced from the local supermarket (bright blue, yellow, pink), secured around the nails with wire and hammered into place on the frame. Like a traditional embaire, this configuration allowed lamellas to vibrate freely upon striking, mimicking acoustic behaviour.

We also created resilient mallets using used discarded skateboard wheels attached to drumsticks (Figure 4, bottom).

4.2 Sensing Network

Each lamella's underside, the side with the grip tape, hosted a networked array of 35mm and 20mm piezo sensors, connected via copper tape (we took this approach due to wire scarcity). We affixed the piezos to the boards with salvaged foam pads, as we found during testing that the sensors would come loose if not firmly attached, and discovered that the foam pads stuck to the grip tape particularly well (Figure 5).

Signals from all eight networks fed into a Bela Mini multichannel system as audio-rate inputs. Because we used the audio inputs we could apply per-channel gain adjustments to provide lamella-specific normalisation. We applied signal conditioning on the Bela Mini (low-pass filtering to reject non-strike noise, full-wave rectification for peak detection) across all channels.

On detection of a strike, the Bela Mini initiated a 5ms peak-sampling window and returned the highest value found. This is to control for signal propagation delays, as we knew that the onset was often not the most significant reading of velocity. The Bela Mini then passed the velocity value (between 0 and 1) and the lamella number to the synthesis system via MIDI over USB.

As a percussion instrument, we knew that latency would significantly degrade playability and authenticity. We targeted a total latency of under 10ms with minimal jitter [6], leveraging Bela Mini's hard real-time, jitter-free processing capabilities and the speed of communication of MIDI over USB. As a result, latency was imperceptible, even with vigorous and fast playing.

4.3 Software Implementation

The sounding portion of this DMI was implemented in Pure Data, employing the spectral warping wavetable synthesizer Vital [2]. The patch mapped 8 measured frequencies from the 1948 field notes to the embaire's 8 lamellas, representing a playable subset of a traditional embaire. It received MIDI note and velocity data from the Bela Mini, representing struck lamella and impact force,

[2] https://vital.audio/

Figure 5: Sensing networks on each skate deck.

and routed this to Vital to trigger corresponding pitches and amplitudes.

The software enabled sonic extensions beyond the traditional embaire. We implemented multiple sound designs, including a profile emulating the instrument's characteristic timbre. Bin and Karugu performed the core embaire percussion, while Hugueninn-Virchaux contributed live pitch bending, dynamically altering pitches and timbres during performance. This introduced a third active performer, analogous to the embaire's traditional drummers, who extend its low register. This transformed Hugueninn-Virchaux from passive observer of the live system to integral ensemble member. This also aligns with the character of the embaire; Kubik states that the tuning of the embaire is characterised by its flexibility, but retains its central character: "The different xylophones on which I used to play had only approximately the same scale. Never, of course, did the scale lose its pentatonic identity." [8]

4.4 Observation and Presentation

We occupied the Instruments Makers Lab for two weeks surrounding the festival, enabling extensive visitor interaction. Every visitor recognised the skateboard lamellas immediately, with locals frequently linking them to the area's skate culture.

Though we were iteratively building and refining it over this time, the embaire supported continuous jamming. Its sub-10ms latency [6] encouraged authentic percussive treatment, while extensible sound profiles added modern flair. We performed it as a trio in a live nightclub performance on the festival's closing night, and the process of building the embaire was included in a short documentary on the Instruments Lab[3].

5 Discussion and Reflection

This project starts from historical observations on embaire tuning and reimagines the embaire through Nairobi's material constraints: salvaged skateboards (sourced from the Skate Society above our lab), sponge-wrapped nails as vibration pegs, networked piezos on Bela Mini. These choices respond to local availability while preserving essential character (such as pentatonic tuning and ensemble playability), expressed through Vital synthesis and live pitch-bending.

[3]https://www.youtube.com/watch?v=7LHKYhWxMVY

5.1 Cultural Continuity

The Skateboard Embaire demonstrates that cultural continuity isn't a process of fossilisation, but rather relies the capacity of traditional forms to persist through reinvention. By absorbing local skate culture, sensing, digital synthesis, traditional tuning and material constraints we created a modern instrument that had additional dimensions afforded only by digital technology, but was still legible as an embaire.

We sustained this continuity across three dimensions:

- **Tuning:** Intervals directly from the original lamellas, faithfully reproduced through Vital synthesis
- **Form:** Skateboard lamellas on a 2,5m frame with sponge-wrapped pegs, maintaining the scale, ability to support ensemble playing, and vibration physics
- **Practice:** Collaborative play by multiple people; pitch bending

Nairobi visitors immediately recognised the skateboards as local culture while encountering the embaire, sometimes for the first time. It was playable and accessible, functioning as a living musical instrument, not as a historical artefact. In this way, the Skateboard Embaire is an example of cultural continuity: its traditional forms persist through new materials, technologies, and contexts while retaining essential character. The embaire persists not despite these transformations, but through them, ready for East African makers to continue the chain.

5.2 Making meaning with materials

Paul Gilroy's concept of the 'changing same' describes how cultural continuity is maintained precisely through adaptation and response to new contexts.[3] Tradition persists not through stasis, but through ongoing transformation in dialogue with contemporary circumstances.

This understanding extends to the materiality through which tradition is enacted. As we discussed above, Anthropologist Arjun Appadurai argues that objects carry cultural meaning through their materiality and circulation [1]. Tim Ingold extends this, arguing that tradition lives not in fixed forms, but in the *act of making*, in the practices, skills, and knowledge that practitioners embody and transmit through doing [5]. Ethnomusicologist Thomas Turino similarly argues that musical tradition is participatory; it exists in the doing, in performance and practice, rather

Figure 6: The ensemble performing the embaire

than in preservation of historical forms [14]. These frameworks suggest that the embaire's continuity lies not in maintaining wooden keys or ground-hole resonators, but in the ongoing practice of making, playing, and participating in the embaire as a living musical form. Material and technological change do not necessarily disrupt this continuity; they can be vehicles through which it is sustained and transformed.

5.3 NIME materiality

Artists and technologists building DMIs are not just making technical decisions, but also aesthetic ones. Lepri [9] suggests that this is a 'complex negotiation' with their own tastes and values, what they have at hand, and the aesthetic influences around them, and ultimately embody cultural assumptions. It could be argued that though DMIs present an unparalleled number of degrees of freedom to negotiate, every instrument undergoes this development and represents the cultural, aesthetic, and musical values of its designer.

Our material choices were also motivated by sustainability; we are well aware that East Africa bears a disproportionate burden of the effects of climate change [16], despite the area's relatively low contribution to the problem. Sustainability has also emerged as a critical concern within NIME, with recent strategies, particularly one from Masu et al. [10] emphasising sustainability measures such as recycling, local production, bio-based materials, longevity and so on. Along with these values, the fact of this process taking place in Nairobi meant that we had to be resourceful, as new materials and electronics are in short supply and often salvaged.

5.4 Postcolonial Hybridity

Our embaire redesign occupies Homi K. Bhabha's 'Third Space' [2], a liminal terrain where cultural forms emerge through creative negotiation between inherited practices and contemporary possibilities. This space is neither fully traditional nor fully modern; rather, it is a site for hybrid reinterpretation where heritage remains rooted while responding to present circumstances. In this way, the Skateboard Embaire, as a reimagined traditional instrument leveraging the unique affordances of DMIs, is brought into a contemporary context.

The skateboard is a global symbol of urban youth culture. By choosing it as the resonator for a traditional tuning system, we create what Bhabha calls a 'disruptive' hybridity. This 'Third Space' does not just blend cultures; it creates a new site where the 'authoritative' history of the embaire is translated through the material constraints and creative desires of a modern Nairobi community.

Hybridity here also asserts creative agency: a Kenyan-European collaboration during a Nairobi residency, translating Ugandan xylophone tradition into urban East African DMI practice. Skateboard lamellas visibly hybridise global skate culture with embaire form; sub-10 ms latency [6] enables percussive authenticity; digital sound design extends timbral range without erasing acoustic heritage.

However, such reinterpretation operates within power dynamics that deserve acknowledgment. Digital musical instruments have historically been designed within Western technological and aesthetic frameworks and reflect Western musical assumptions. There is risk in any intervention: that a reimagined embaire becomes aestheticised spectacle, decontextualised from its original cultural functions, consumed as a 'world music' novelty or approximated appropriation lacking context, rather than engaged as living musical practice. As such, we do not claim that we have 'preserved' the embaire authentically. Rather, we aimed for transparency about what we have done: reinterpreted the embaire in a modern Nairobi context, drawing on historical knowledge but making new creative choices, and to acknowledge both what this reimagining enables, what it necessarily transforms, and what it potentially loses.

6 Conclusion

The Skateboard Embaire demonstrates how historical embaire knowledge seeds contemporary DMI innovation within situated constraints. By creating an instrument that was a hybrid assembly of skateboards, real-time sensing, and digital synthesis, we created a playable instrument that preserves the embaire's core characteristics while extending its expressive range.

We invite East African makers to extend this embaire, building their own hybrid variants from whatever materials define their moment. The tradition continues through exactly this process of living reinterpretation.

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8 Ethical Standards

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This work presents no implicit or explicit conflicts of interest.

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