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Digital Heritage as Pedagogy: Fostering Cultural Identity through the Preservation of Guizhou Dong and African Vernacular Architecture

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Abstract

This paper undertakes a comparative examination of two geographically distant but conceptually convergent traditions of vernacular building: the timber architecture of the Dong ethnic minority in Guizhou, China — epitomised by the drum tower (gulou) and wind-and-rain bridge — and the earthen and painted vernacular forms of sub-Saharan Africa, exemplified by Dogon settlement architecture in Mali and Ndebele mural-house traditions in southern Africa. Both traditions encode cosmology, kinship, and social order into built form through non-textual, highly structured sign systems that are transmitted primarily through oral instruction and communal practice rather than written codification. Framing architecture as a semiotic artefact, the study draws on Peircean and structuralist theories of the sign, together with anthropological readings of vernacular form, to compare how spatial layout, ornament, colour, and structural grammar function as culturally specific languages. The paper then evaluates how digital preservation technologies — including UAV and terrestrial photogrammetry, LiDAR scanning, Historic Building Information Modelling (HBIM), and community-based digital archiving — have been deployed to document these traditions, using the Decoding Dong project in Guizhou and comparable African heritage-documentation initiatives as illustrative cases. The analysis argues that digital preservation of vernacular heritage cannot be reduced to geometric capture alone; it must also register the semiotic and performative dimensions of these architectures, or risk producing accurate but meaningless digital shells. The paper proposes an integrated framework combining reality-capture technologies with ethnographic and oral-history documentation, and concludes with recommendations for community-engaged, semiotically literate digital heritage practice applicable across both regional contexts.

Keywords: Indigenous Knowledge Systems, Cultural Identity, Heritage Education, Community Engagement, Collective Memory, Technology-Enhanced Learning, Digital Pedagogy

Introduction

Vernacular architecture — building produced outside formal professional or academic design institutions, using local materials, inherited techniques, and communally validated forms — constitutes one of the largest and least documented bodies of human cultural production. Because such architecture is rarely accompanied by written design theory, its meanings are carried in the forms themselves: in proportion, orientation, ornament, colour, and the sequencing of ritual and daily use through space. This paper treats two such traditions as comparative case studies. The first is the architecture of the Dong (Kam) people of southwestern China, concentrated across Guizhou, Hunan, and Guangxi provinces, whose villages are organised around the drum tower (*gulou*), a multi-eaved timber pavilion that functions simultaneously as a landmark, a council chamber, and a cosmological marker of communal identity. The second is a constellation of sub-Saharan African vernacular forms, represented here principally by the settlement architecture of the Dogon of the Bandiagara escarpment in Mali and the painted homestead traditions of the Ndebele of South Africa and Zimbabwe, with reference to the wider corpus of earthen Sahelian building exemplified by the Great Mosque of Djenné.

Although separated by geography, climate, material palette, and historical trajectory, both traditions share a structural feature relevant to heritage studies: architectural form operates as a socially legible sign system, and that system is reproduced almost entirely through oral transmission, apprenticeship, and communal labour rather than through drawn plans or written treatises. This has two consequences of direct relevance to preservation practice. First, the loss of a single generation of builders, or the disruption of the ritual occasions on which building knowledge is transmitted, can sever a chain of knowledge that has no parallel textual record. Second, conventional heritage documentation — measured drawings, photographs, even three-dimensional geometric capture — can preserve the outward form of a structure while leaving its semiotic content, the meanings that made the form significant to its builders and users, undocumented and therefore effectively unrecoverable.

Many indigenous communities are facing a loss of cultural identity and the transmission of traditional knowledge from one generation to the next as a result of globalization, urbanization and rapid digital change. While digital heritage technologies have made a great step forward in the documentation and preservation of historic architecture, the ways in which these technologies can be used to enhance cultural learning, build community identity, and facilitate heritage education have yet to be fully investigated. Digital heritage, therefore, must be seen as a pedagogical and social platform that allows the transmission of culture, the participation of the

community and the preservation of indigenous knowledge for future generations, in addition to being a technological solution for the recording of physical structures. In this context, this study examines the potential of digital preservation of Guizhou Dong and African vernacular architecture in the promotion of cultural identity and heritage education from a comparative point of view.

The rapid expansion of digital reality-capture technologies over the past decade — UAV photogrammetry, terrestrial laser scanning, and increasingly automated Historic Building Information Modelling (HBIM) workflows — has transformed the feasibility of large-scale vernacular heritage documentation. Projects such as the Decoding Dong initiative, which combined LiDAR scanning, aerial and terrestrial photogrammetry, and oral-history recording across roughly a hundred historic Dong buildings in Guizhou, demonstrate both the power and the limits of these tools. This paper asks two linked questions. First, what do comparative semiotic readings of Dong and African vernacular architecture reveal about how meaning is encoded in built form across culturally distinct but structurally analogous traditions? Second, how might digital preservation practice be reoriented to capture not only the geometry but also the semiotic and performative dimensions of such architecture, and what does a comparison of current practice in Guizhou and in African heritage contexts suggest about best practice going forward?

2. Theoretical Framework: Architecture as Sign System

2.1 Semiotics of the Built Environment

The application of semiotic theory to architecture rests on the proposition that built form communicates meaning through denotative and connotative codes in the same manner as language, image, or ritual. Umberto Eco's influential account of architecture as a system of signs distinguishes the primary, denotative function of a building — sheltering, enclosing, dividing space — from its secondary, connotative functions, through which form comes to signify status, cosmology, or ideology beyond bare utility. Roland Barthes's semiological reading of urban form similarly treats the city and its structures as texts to be read, while Amos Rapoport's anthropological account of house form as a product of sociocultural rather than purely climatic or technical determinants provides the comparative anchor for the present study: house and settlement form, in Rapoport's framework, expresses a worldview, and that worldview can be read comparatively across unrelated cultural traditions that nonetheless organise space around shared human concerns such as kinship, gender, ancestry, and cosmological order.

For the purposes of this comparison, three semiotic registers are distinguished. The first is spatial syntax — the arrangement of built and open space at the settlement scale, which encodes social hierarchy, lineage structure, and communal versus private domains. The second is structural grammar — the visible logic of joinery, framing, and load-bearing elements, which in traditions without written architectural theory often carries mnemonic and pedagogical functions, encoding construction

knowledge in a form legible to apprentice builders. The third is applied ornament — colour, pattern, carving, and surface treatment, which frequently operates as the most explicit and most consciously manipulated communicative layer, capable of encoding status, marital state, clan affiliation, or protective and spiritual function.

2.2 Digital Heritage as a Preservation and Interpretive Practice

Digital heritage documentation is often presented in technical terms, as a problem of geometric accuracy, point-cloud density, or model completeness. Historic Building Information Modelling (HBIM), first articulated by Murphy, McGovern and Pavia as an extension of BIM workflows to historic fabric, reframes reality-capture data as a parametric, queryable model rather than a static record, allowing structural, material, and historical information to be layered onto geometry. This capacity is significant for vernacular heritage because it opens the possibility of embedding non-geometric, semiotic information — a colour's symbolic meaning, a joint's ritual name, a spatial threshold's social significance — directly into the digital record, rather than leaving such information in separate, easily disconnected ethnographic archives. However, the literature on HBIM and reality capture has developed primarily around monumental and institutional heritage, where design intent is documented and archived; its extension to vernacular, orally transmitted traditions requires deliberate methodological adaptation, which this paper argues should be guided by the semiotic framework outlined above rather than treated as a purely technical afterthought.

The recent development of sociological and cultural studies research on cultural heritage has highlighted the fact that cultural heritage is not an object of the past but a social process in which communities build collective memory, affirm cultural identity and pass on the values they hold across generations. Accordingly, the preservation of vernacular architecture should not only focus on the documentation of physical buildings, but also on the preservation of the cultural meanings, traditional practices and indigenous knowledge that are embedded in the buildings. Collective memory theory also elucidates that historic buildings serve as cultural icons that reinforce the sense of community and social cohesion by representing history and memory. In the educational context, the use of technology in learning has become an effective means of raising awareness of heritage and cultural learning through digital media. The interactive technologies such as digital archives, virtual museums, 3D models, immersive visualization, and online heritage repositories create innovative learning environments that have the potential to involve the public, to engage them in learning, and to facilitate the transfer of knowledge from one generation to the next. These online learning spaces allow younger generations to connect with traditional culture and promote lifelong learning and community-based cultural education.

Additionally, recent research on community engagement highlights the need to engage local communities in the documentation, interpretation, and dissemination of

indigenous knowledge in sustainable digital heritage projects. Participatory digital heritage practices, in addition to enhancing the authenticity and inclusiveness of preservation, also enable communities to hold onto their cultural stories. Thus, the combination of the views of sociology, cultural studies, heritage education, collective memory and technology-enhanced learning offers a comprehensive theoretical basis for the understanding of digital heritage as a multidisciplinary approach that can contribute to the cultural identity, educational development, participation of communities and sustainability of indigenous architectural heritage in the long term.

3. Methodology

This study adopts a comparative, qualitative research design combining architectural semiotic analysis with a review of digital heritage documentation practice. Primary architectural description is drawn from the published scholarly literature on Dong drum towers and settlements and on Dogon, Ndebele, and broader Sahelian vernacular architecture, supplemented by recent digital-heritage project reports, including the Decoding Dong documentation initiative in Guizhou. Sources were selected to represent (a) architectural-historical and ethnographic descriptions of built form and its social function, (b) conservation-science studies addressing material and structural condition, and (c) digital-documentation and HBIM studies reporting specific technological workflows and outcomes. The two regional case studies are analysed in parallel using the three-register semiotic framework — spatial syntax, structural grammar, applied ornament — introduced in Section 2, and the resulting readings are synthesised in a comparative matrix (Table 1). Digital preservation approaches identified in the literature are then assessed against the same three registers to determine which are, and are not, currently captured by prevailing reality-capture and HBIM workflows. As a comparative literature-based study rather than an original fieldwork or digital-capture project, the analysis is necessarily limited by the depth and availability of published documentation for each tradition; this limitation is addressed further in Section 8.

The selection of Guizhou Dong architecture and African vernacular architecture was based on a purposive comparative research design, because both of them are indigenous architecture that reflects cultural identity, traditional knowledge and community values through built form in different geographical and cultural backgrounds. In spite of the differences in materials, environmental conditions, and historical development, the two traditions share some similar features: high levels of community involvement, oral transmission of construction knowledge, symbolic expression of architecture, and growing exposure to globalization and cultural change. These common traits serve as a suitable platform for a comparative analysis across cultures, and help to identify universal and context-specific solutions to digital heritage preservation. The comparative analysis is carried out by means of architectural semiotic approach which sees architecture as a system of cultural signs that transmits social meanings in physical form. The framework explores three complementary analytical aspects: spatial syntax (settlement organization and

spatial relationships); structural grammar (construction systems, material logic and indigenous craftsmanship); and applied ornament (decorative motifs, colour, carving and symbolic representations related to cultural identity and collective memory). These analytical dimensions offer a uniform theoretical framework for the analysis of both case studies and for a comparison that goes beyond the physical aspects of architecture to social, cultural, educational and symbolic aspects. In addition, the comparative process entails a systematic analysis of the literature to determine the similarities and differences between the two traditions, as well as to assess the extent to which current digital preservation technologies capture tangible architectural features and intangible cultural knowledge in vernacular architecture. This methodological approach improves the transparency, consistency and academic rigour of the comparative analysis and, in line with the study's updated interdisciplinary approach, allows for the study to be linked to the themes of digital heritage, cultural identity and heritage education.

4. Case Study I: Guizhou Dong Architecture

4.1 Settlement Logic and the Drum Tower as Cosmogram

Dong villages in southern Guizhou, western Hunan, and northern Guangxi are organised around one or more drum towers, timber pavilions rising in a stepped, pagoda-like series of eaves from an open ground-floor hall. The drum tower is not a religious building in the sense of housing a deity, but functions as the civic and cosmological centre of the settlement: villagers gather beneath it to deliberate on communal affairs, resolve disputes, and mark seasonal and life-cycle events, while its silhouette — visible above the surrounding stilt houses and terraced fields — orients the settlement and signals clan or sub-lineage identity to outsiders and to Dong travellers from other villages. Where a village contains several kinship groups, each may build and maintain its own drum tower, so that the settlement's skyline becomes a legible map of its social structure; the number, position, and relative height of towers communicates lineage organisation as directly as any written census. Recent design-preference research across multiple Dong village clusters in Guangxi confirms that this settlement-level legibility is not incidental but a persistently reproduced design value across communities.

4.2 Wind-and-Rain Bridges and Stilt Dwellings

Complementing the drum tower, the covered wind-and-rain bridge (fengyu qiao) spans the streams that typically divide Dong settlements, combining a practical crossing function with covered seating that serves, like the drum tower, as an informal gathering space. Its presence at the settlement's edge or centre marks thresholds between kin groups or between the village and the surrounding landscape, extending the drum tower's civic function into a linear, processional register. Domestic architecture, by contrast, follows the ganlan or stilt-house typology common across much of southern China's ethnic minority regions: raised timber dwellings that separate living quarters from livestock and storage below, adapted to

the region's steep, humid terrain. The relative modesty and structural repetition of domestic stilt houses, set against the singular, elaborated form of the drum tower, itself constitutes a semiotic contrast: private, replicable dwelling versus unique, communally invested monument.

4.3 Structural Grammar and Oral Transmission

The drum tower's structural system is built entirely from timber joined by mortise-and-tenon joinery, without nails, using either the chuan-dou (column-and-tie) or tai-liang (post-and-beam) framing typologies documented in conservation studies of Dong wooden structures. Master carpenters historically worked without written plans, relying on scaled bamboo or wooden calculation rods and on orally transmitted proportional rules passed from master to apprentice; because the Dong language, though rich in oral literature, historically lacked a standard written script, construction knowledge exists nowhere except in built precedent and in the carpenters' memory and practice. This condition, noted explicitly in recent digital-reconstruction studies of endangered Dong drum towers, makes the structural grammar of the drum tower simultaneously an engineering solution and a pedagogical and mnemonic document: the visible logic of joints and framing is, in effect, the only surviving textbook. It is also, from a semiotic perspective, the register most vulnerable to complete loss, since its meaning cannot be recovered from surface appearance alone if the line of oral transmission is broken.

The framework is composed of five steps, which include the use of digital technologies, cultural interpretation, community involvement and education dissemination, all of which contribute to the sustainable preservation of indigenous architectural heritage. The process starts with Heritage Documentation, which involves gathering architectural and cultural information via aerial surveys, photogrammetry, LiDAR scanning, oral history interviews and archival research. This stage creates detailed digital records of the physical features of heritage buildings, as well as the indigenous knowledge. The documented information is then subjected to Semiotic Interpretation, where the architectural heritage is analysed based on three semiotic dimensions: spatial syntax, structural grammar and applied ornament and symbolism. At this stage, cultural meanings, social functions, construction knowledge and symbolic representations can be identified within the vernacular architecture. The information is then converted to digital assets using Digital Preservation Technologies after the semiotic analysis. The use of advanced technologies like three-dimensional modelling, point cloud processing, texture mapping, digital archiving and online repositories enable the production of accurate and accessible digital representations of the heritage resources. The fourth stage is Community Participation, where communities are actively involved in documentation, validation, sharing of indigenous knowledge and capacity building. Community involvement helps to make the preservation process culturally authentic and help in passing on traditional knowledge from one generation to the next, as well as strengthening local ownership of traditional heritage resources. Last but not least, the workflow

culminates in Educational Outcomes and Dissemination, where digital heritage resources are embedded in heritage education, virtual learning environments, museums, exhibitions and public outreach programs. These educational uses foster cultural understanding, build community identity, and support sustainable indigenous architectural heritage. Several elements enable the workflow, such as interdisciplinary collaboration, ethical documentation practices, data security, sustainability, and institutional policy support, all of which ensure the effectiveness and long-term applicability of digital preservation initiatives. In general, the proposed framework illustrates that digital heritage preservation is not merely about the documentation of physical architecture, but also about technological innovation, cultural interpretation, community involvement and educational dissemination, aimed at preserving the tangible and intangible values of the Guizhou Dong and African vernacular architecture.

5. Case Study II: African Vernacular Architecture

5.1 The Dogon Toguna and Domestic Cosmology (Mali)

The Dogon of the Bandiagara escarpment in central Mali, who settled the cliff face after the earlier Tellem inhabitants, developed a settlement and house form widely cited in architectural anthropology as an explicit cosmogram. Dogon compounds are frequently described, in both ethnographic and popular architectural literature, as organised on a body-and-ancestor logic in which the layout of a family compound corresponds symbolically to a human figure, with exterior walls read as the body and internal chambers assigned to spirit and lineage functions. The toguna, the low-roofed communal shelter where village elders meet, is conventionally built with eight carved pillars, each said to represent one of the Dogon's eight primordial ancestors, so that the act of gathering beneath the toguna is simultaneously a practical deliberative act and a ritual re-enactment of founding lineage structure — a function directly analogous to the Dong drum tower's combination of civic assembly and lineage commemoration, though expressed through a different formal vocabulary (a low, deliberately cramped shelter that discourages standing disputes, rather than a soaring vertical landmark).

5.2 Ndebele Mural Geometries as Encoded Communication

The Ndebele of South Africa and Zimbabwe developed, particularly from the period of forced displacement and labour under colonial and Boer administration in the eighteenth and nineteenth centuries, a tradition of painting geometric murals on the exterior walls of homesteads. What began, according to accounts of the tradition's origin, partly as a means for women to communicate grief and cultural resistance under conditions of political domination, evolved into an elaborate visual code using an established palette in which black conventionally signals connection to the spiritual and ancestral realm, white signals purity, and red signals passion or vitality, combined into precise geometric patterns capable of communicating a homeowner's status, the announcement of a marriage, or other significant household events.

Because this code is applied to the building's surface rather than embedded in its structural logic, it functions as the most overt and most rapidly legible of the three semiotic registers, comparable in communicative directness to signage, even as its underlying grammar — the specific combinations of colour and geometric motif — requires cultural literacy to decode fully.

5.3 Earthen Monumentality: The Great Mosque of Djenné and Sahelian Building

Beyond the Dogon and Ndebele traditions, the wider Sahelian and West African vernacular corpus — encompassing mud-and-wattle construction, thatched circular dwellings such as the Zulu homestead, bamboo lattice construction among the Baganda of Uganda, beehive-form huts among the Himba of Namibia, and coral-rag construction along the Swahili coast — demonstrates a shared regional logic in which locally available materials are shaped into forms that simultaneously solve thermal and structural problems and encode cultural meaning through form, roofline, and settlement arrangement. The Great Mosque of Djenné, a UNESCO World Heritage Site rebuilt annually through communal plastering, exemplifies how earthen monumental architecture in this region depends for its continued existence on an annual, participatory ritual of maintenance; the building's physical survival and its social meaning are therefore inseparable, since the mosque's material presence each year is itself the product, and the proof, of communal cohesion — a dynamic with clear parallels to the Dong drum tower, whose periodic repair and rebuilding likewise functions as an occasion for reaffirming lineage and communal ties (Table 1).

Table 1. Comparative Analysis of Semiotic Features of Guizhou Dong and African Vernacular Architecture

Semiotic Dimension	Guizhou Dong Architecture	African Vernacular Architecture	Comparative Interpretation
Spatial Syntax (Settlement Organization)	Villages are organized around drum towers that function as civic, cultural, and clan centers. Wind-and-rain bridges connect different settlement areas and symbolize social cohesion.	Dogon settlements are organized according to ancestral cosmology, while toguna structures serve as communal meeting spaces. Circular compounds reflect kinship and social hierarchy.	Both architectural traditions employ spatial organization to reinforce community identity, collective memory, and social relationships through culturally meaningful settlement layouts.
Structural Grammar (Construction Logic)	Timber mortise-and-tenon construction is transmitted through master-apprentice learning and represents accumulated indigenous engineering knowledge.	Earthen, stone, timber, and mud-brick construction techniques are transmitted through oral tradition and communal participation, reflecting environmental	Construction systems in both traditions function not only as engineering solutions but also as repositories of indigenous knowledge passed across generations.

Semiotic Dimension	Guizhou Dong Architecture	African Vernacular Architecture	Comparative Interpretation
Applied Ornament and Symbolism	Decorative roof forms, carved wooden details, and drum tower silhouettes symbolize clan identity, cultural beliefs, and communal values.	Ndebele geometric murals, carved pillars, and decorative motifs communicate social status, ancestral beliefs, cultural identity, and important life events.	Decorative elements act as visual languages that preserve symbolic meanings, strengthen cultural identity, and communicate social values within each community.
Knowledge Transmission	Traditional construction knowledge is preserved through oral instruction, apprenticeship, festivals, and collective building practices without formal written documentation.	Indigenous knowledge is transmitted through storytelling, ritual practices, mural painting, communal construction activities, and intergenerational learning.	Both traditions depend heavily on oral transmission and community participation for preserving architectural knowledge and maintaining cultural continuity.
Community Function	Drum towers and bridges provide spaces for public meetings, festivals, conflict resolution, and community decision-making.	Toguna structures, village compounds, and communal spaces support social gatherings, cultural ceremonies, and collective governance.	Architecture functions as a social institution that promotes community interaction, strengthens cultural identity, and supports social cohesion.
Educational Value	Traditional architecture provides experiential learning opportunities by teaching construction techniques, cultural values, and indigenous knowledge to younger generations.	Vernacular buildings, murals, rituals, and communal activities serve as informal educational resources for preserving cultural traditions and collective memory.	Both architectural traditions serve as living educational environments that facilitate cultural learning, heritage awareness, and intergenerational knowledge transmission.
Preservation Vulnerabilities	Loss of traditional craftsmen, urbanization, commercialization, and declining apprenticeship systems threaten the continuity of Dong architectural heritage.	Modernization, migration, changing lifestyles, environmental degradation, and the decline of traditional	Both traditions face similar risks associated with globalization and cultural transformation, highlighting the need for integrated digital preservation and

Semiotic Dimension	Guizhou Dong Architecture	African Vernacular Architecture	Comparative Interpretation
		craft practices threaten vernacular heritage.	community-based conservation strategies.
Digital Heritage Opportunities	LiDAR scanning, photogrammetry, HBIM, GIS mapping, and oral history documentation support digital preservation and educational dissemination.	Photogrammetry, digital archives, GIS mapping, virtual exhibitions, community documentation, and digital storytelling enhance preservation and public engagement.	Digital heritage technologies support not only architectural documentation but also cultural identity, community participation, heritage education, and sustainable preservation across both traditions.

6. Comparative Aesthetic-Semiotic Analysis

Read together, the Dong and African case studies suggest that vernacular architectures separated by geography and material culture can converge on strikingly similar semiotic strategies, while diverging sharply in the specific register through which meaning is made most explicit. In both traditions, a communal gathering structure — the drum tower, the toguna — functions as a cosmogram: a built form whose geometry, siting, and use choreograph and commemorate lineage and communal order simultaneously. In both traditions, domestic architecture is comparatively standardised and its semiotic content muted relative to the communal landmark, though the Ndebele case complicates this pattern by relocating rich symbolic communication onto the domestic wall surface itself, via mural rather than communal-monument form. Structural grammar carries the heaviest semiotic and epistemic burden in the Dong case, where joinery is simultaneously an engineering system and an oral pedagogical archive, whereas in the African cases examined here, applied surface treatment (Ndebele) and annual participatory ritual (Djenné) carry a comparatively greater share of the communicative and social-reproduction function. Table 2 summarises this comparison across the three registers identified in Section 2.

Semiotic Register	Guizhou Dong Architecture	African Vernacular Architecture
Spatial syntax (settlement scale)	Drum tower(s) mark lineage groups within the village; number and placement of towers map social structure; wind-and-	Dogon compound layout follows a body/ancestor schema; toguna siting anchors elder deliberation to founding-ancestor symbolism; circular Zulu homestead plans

Semiotic Register	Guizhou Dong Architecture	African Vernacular Architecture
	rain bridge marks kin/territorial thresholds.	encode kin hierarchy around a central cattle byre.
Structural grammar (construction logic)	Nail-free mortise-and-tenon timber framing (chuan-dou / tai-liang systems) transmitted orally by master carpenters; joinery functions as a mnemonic 'text' in a tradition without a standard written script.	Toguna's low, eight-pillar frame encodes ancestral number symbolism directly into load-bearing structure; earthen coursing and communal replastering of Djenné-type mosques encode participatory, seasonally renewed construction knowledge.
Applied ornament (surface/colour/carving)	Comparatively restrained; decorative emphasis falls on the tower's silhouette, roof-eave profile, and occasional carved or painted motifs rather than wall surface.	Ndebele geometric wall murals form an explicit, legible colour-and-pattern code communicating status, marital events, and spiritual affiliation; Dogon carved doorways and ancestor sculpture add a secondary symbolic layer to domestic facades.
Primary mode of transmission	Oral instruction and apprenticeship between master carpenters and successors; no standard written architectural script for the Dong language.	Intergenerational, often gendered transmission (e.g., mural painting passed among Ndebele women); communal ritual labour (mosque replastering) as a transmission mechanism in its own right.
Principal preservation vulnerability	Loss of master carpenters severs the only record of structural grammar; tourism-driven replica towers detach form from	Interruption of ritual maintenance (e.g., annual replastering) or of gendered craft transmission (mural painting) can arrest both

Semiotic Register	Guizhou Dong Architecture	African Vernacular Architecture
	settlement and lineage context.	physical survival and symbolic legibility.

Table 2. Comparative semiotic registers in Dong and African vernacular architecture.

The framework starts with Data Acquisition (Heritage Documentation), where the architectural and cultural data is acquired through various documentation methods, such as using the Unmanned Aerial Vehicle (UAV) for aerial surveys, photogrammetry, LiDAR scanning, oral history interviews, and archival research. These complementary approaches create detailed digital archives of the physical structures and the indigenous knowledge that exists within them that is embodied in Guizhou Dong and African traditional architecture. The acquired information is then analysed in the context of Semiotic Interpretation, thus the architectural heritage is treated as a system of cultural signs. This stage investigates three complementary aspects: spatial syntax, structural grammar and applied ornament and symbolism. The concepts of spatial syntax analyse the organisation of settlements and social relationships, structural grammar deals with the indigenous building techniques and craftsmanship, and the applied ornament deals with the interpretation of the decorative elements, cultural symbols, and collective identity represented in the built environment. The information is then converted using Digital Preservation Technologies after the semiotic analysis. At this stage, the HBIM modelling, point cloud processing, texture mapping, material mapping, digital archiving, and GIS integration are used to create accurate digital models of heritage resources. The products created in this stage are three-dimensional models, digital archives, metadata repositories and geospatial databases, all of which are stored, managed and disseminated in a central Digital Heritage Repository. The fourth stage is focused on Community Participation and Knowledge Integration, acknowledging the importance of local communities in the preservation process. Community participation is through participatory documentation, sharing of indigenous knowledge, validation of digital content and capacity building. This way of working enhances the authenticity of digital records, enhances intergenerational knowledge transfer and boosts community ownership of cultural heritage. Lastly, the framework delivers a number of Educational and Social Outcomes, such as heritage education, immersive digital experiences, museum exhibitions, public outreach programs, sustainable preservation strategies and strengthened cultural identity. The results show that digital heritage can not only serve as a preservation technology, but it can also be an educational tool that raises cultural awareness and fosters community involvement and lifelong learning. A series of cross-cutting enablers are included in the

framework: interdisciplinary collaboration, ethical and culturally sensitive documentation practices, data security and privacy, environmental sustainability, and institutional policy support. The enabling components guarantee the technical reliability, cultural appropriateness, social inclusion and long-term sustainability of digital heritage projects. In summary, the proposed framework offers a comprehensive strategy that links heritage documentation, semiotic analysis, digital technologies, community engagement, and educational outreach to ensure the conservation of the tangible and intangible heritage values of Guizhou Dong and African vernacular architecture, as well as promote cultural identity and sustainable heritage management.



Figure 1. Comparative Analysis of Semiotic Features of Guizhou Dong and African Vernacular Architecture

The values represent normalized comparative scores (0–100) derived from the qualitative assessment framework adopted in this study. Higher scores indicate a stronger representation of the corresponding semiotic dimension. The comparison highlights that Guizhou Dong architecture exhibits stronger structural grammar and knowledge transmission through timber craftsmanship and apprenticeship, whereas African vernacular architecture demonstrates greater richness in applied ornament and symbolic visual communication. Both architectural traditions show consistently high scores in spatial syntax, community function, and educational value, reflecting their shared importance in preserving cultural identity and indigenous knowledge.

7. Digital Preservation Approaches: A Comparative Technological Review

7.1 The Decoding Dong Project

The most sustained recent effort to digitally document Dong architectural heritage is the Decoding Dong project, an interdisciplinary initiative launched in 2023 and completed in 2025 that combined 3D LiDAR scanning, aerial and terrestrial photogrammetry, three-dimensional reality-capture modelling, measured drawing, documentary filmmaking, and mapping, complemented by oral-history recording undertaken with Dong community members. The project produced digital and audio-

visual documentation of approximately one hundred historic buildings across a dozen remote Dong villages, generating outputs such as cross-sectional axonometric drawings that expose the wooden tectonics of individual drum towers. Separately, conservation-oriented digital-reconstruction studies of endangered drum towers, such as work on the Zengchong tower, have combined manual measurement with two-dimensional imaging and oblique UAV photography to reconstruct construction sequences in detail, while more recent research has applied machine-vision techniques to automate HBIM generation for Dong timber structures directly from photogrammetric and drawing data, reporting detection accuracy above ninety percent for structural elements and substantial efficiency gains over manual HBIM modelling. Notably, several of these projects explicitly frame their motivation in semiotic terms: researchers and journalists documenting the Decoding Dong initiative have highlighted the risk that commercially built, standalone replica drum towers erected for tourism — disconnected from surrounding houses, forests, and lineage context — represent a loss of settlement-level meaning even where the individual structure is faithfully reproduced, underscoring that geometric fidelity alone does not guarantee semiotic preservation.

7.2 African Digital Heritage Initiatives

Digital documentation of African vernacular architecture has developed less as a single coordinated national programme than as a distributed set of academic, conservation, and cultural-institution projects. Comparative photogrammetric surveys of vernacular mosque architecture across North and West African and adjacent regions have combined image-based reality capture with structured typological databases, explicitly designed to be extensible through LiDAR, drone survey, or geospatial modelling, and oriented toward practical use by heritage authorities and local administrations rather than academic publication alone. Digital object and cultural-heritage archives such as Digital Benin, which documents artefacts and material culture associated with the historic Kingdom of Benin, illustrate a complementary strand of African digital heritage work focused on movable material culture and archival reconstruction rather than standing-structure capture. Compared to the Decoding Dong project's integrated combination of LiDAR, photogrammetry, and oral history across a defined ethnic-architectural corpus, published African vernacular-architecture digitisation work reviewed for this study appears more fragmented by country, institution, and building type, though individual projects — particularly mosque and earthen-monument documentation — show methodological sophistication comparable to the Dong case.

7.3 Comparative Assessment: What Current Workflows Capture and Omit

Assessed against the three-register semiotic framework introduced in Section 2, current digital-preservation workflows in both contexts perform strongly on structural grammar and spatial syntax at the level of individual buildings: photogrammetry, LiDAR, and HBIM are, by design, well suited to capturing joinery

logic, framing systems, and precise spatial geometry, and the Dong HBIM automation research and the Djebel Amour mosque database both demonstrate high-fidelity capture at this scale. Performance is markedly weaker, however, on settlement-level spatial syntax — the relational meaning carried by a tower's position relative to other towers, or a compound's position relative to lineage neighbours — which requires documentation methods (mapping, GIS, oral testimony about social relationships) that are typically treated as supplementary to the primary geometric capture rather than integrated with it. Applied ornament and colour symbolism, central to the Ndebele case and significant in Dogon carving, are the register most likely to be recorded as an image rather than as structured, queryable data; photogrammetric and LiDAR outputs capture colour and surface pattern visually but rarely encode the symbolic meaning of a specific colour combination or motif within the digital model itself, leaving that information dependent on separate ethnographic annotation. The Decoding Dong project's explicit pairing of reality capture with oral-history recording represents the most methodologically complete response identified in this review to the risk that digital preservation captures form without meaning, and offers a transferable model for African vernacular contexts where comparable oral and ritual-practice documentation is not yet as systematically integrated with geometric capture.

8. Discussion: Convergences, Divergences, and Ethical Tensions

The comparison developed in this paper points to three broader implications for digital heritage practice. First, both case studies confirm that vernacular architecture without a written design tradition places an unusually heavy documentary burden on whichever medium is used to record it, since there is no parallel textual archive against which a digital model can be checked or into which it can be absorbed; this makes the digital record, once created, disproportionately important, and disproportionately risky if it is incomplete or decontextualised. Second, the tourism-driven replication of drum towers in Guizhou and the museification pressures noted in Dogon country in Mali, where UNESCO World Heritage status has itself been described as placing residents at risk of being treated as living exhibits, indicate a shared regional tension between heritage visibility and heritage authenticity that digital documentation can either mitigate or, if used carelessly as a template for further replica construction, exacerbate. Third, the annual replastering ritual at Djenné and the periodic rebuilding of Dong drum towers suggest that in both traditions, physical maintenance is not incidental to but constitutive of cultural meaning; a digital model that treats a building as a fixed artefact to be captured once, rather than as a periodically renewed communal process, risks freezing a living tradition into a static representation that misrepresents its actual mode of cultural survival.

These convergences should not obscure important divergences that limit direct methodological transfer between the two contexts. Dong heritage documentation benefits from a comparatively unified ethnic-architectural corpus (the drum tower as

a single, well-defined building type across a contiguous multi-province region) and from recent, well-resourced interdisciplinary projects; African vernacular architecture, by contrast, spans a far larger number of distinct ethnic traditions, material palettes, and national heritage institutions, making a single continent-wide digitisation strategy considerably harder to coordinate. Ethical practice in both contexts requires that digital documentation be undertaken with, rather than merely of, source communities: oral-history recording, community-controlled data-sharing agreements, and involvement of local builders and elders in validating semiotic interpretation are necessary safeguards against the extraction of cultural knowledge without corresponding benefit or consent, a concern equally applicable to Dong carpenters' embodied structural knowledge and to Ndebele women's mural-painting tradition.

In addition to the documentation of architectural forms and the conservation of symbolic values, there are many social aspects of digital heritage preservation that affect the indigenous population, educational institutions, policymakers and cultural heritage institutions. Digital preservation projects require the co-operation of a variety of actors, such as local communities, traditional craftsmen, heritage studies experts, teachers, museums, government bodies, and digital technology experts. The technical accuracy of the preservation process is assured by the different knowledge and expertise each stakeholder brings, while cultural authenticity and indigenous ownership are respected. The participation of the community is especially significant because the local people are not only the beneficiaries of preservation projects but the actual keepers of the cultural knowledge that is embedded in the vernacular architecture. Digital preservation is also an important element in supporting cultural identity and reinforcing the ownership of the community. The project captures and preserves the traditional construction techniques, oral histories, symbolic decorations, and indigenous craftsmanship, providing communities with opportunities to pass down and share their culture with future generations. Accessible digital archives raise visibility of TK and promote cultural continuity and intergenerational knowledge transfer, cultural pride, and community ownership. Participatory methods involve local communities in heritage management, rather than relying on externally imposed conservation strategies to act as passive observers.

Moreover, digital heritage resources offer great didactic potential for heritage education in formal and informal settings. 3D models, virtual reality experiences, digital museums, interactive exhibitions and online heritage repositories can be used in the school curriculum, university education, museum exhibitions and community learning programs. They offer digitally immersive and interactive learning opportunities for students to explore the traditional architecture, gain understanding of indigenous construction knowledge and appreciate the cultural values of vernacular heritage. Technology-enhanced learning thus turns digital heritage into an educational platform, offering a way to foster cultural awareness, historical understanding, and lifelong learning. On a more general social science level, the comparative study shows that the

preservation of digital heritage can not only help protect architectural heritage, but can also play a role in reinforcing collective memory, supporting indigenous knowledge systems, involving the community and fostering inclusive cultural development. The use of digital technologies in education and in community engagement creates a sustainable framework where architectural heritage is not only a resource but a resource that can be constantly used to sustain cultural identity, social resilience and heritage education. Digital preservation should therefore be considered as a multi-disciplinary approach that involves technological innovation, social involvement, educational empowerment and cultural sustainability.

9. Toward an Integrated Framework for Semiotically-Informed Digital Preservation

Building on the comparative analysis above, this paper proposes that digital preservation projects addressing orally transmitted vernacular architecture should be structured around four linked components rather than reality capture alone. First, geometric capture (photogrammetry, LiDAR, UAV survey) should remain the technical foundation, given its demonstrated accuracy for structural grammar. Second, this geometric layer should be paired systematically, not incidentally, with oral-history and craft-practice documentation, recorded with the builders, elders, or ornament-makers who hold living knowledge of a structure's construction logic and symbolic content, following the model demonstrated by the Decoding Dong project's combination of reality capture with community oral testimony. Third, settlement-scale relational data — the position of a tower or compound relative to lineage neighbours, the social meaning of thresholds such as the wind-and-rain bridge or compound entrance — should be captured through mapping and GIS layers integrated with, rather than separated from, the building-scale HBIM model. Fourth, symbolic and colour-coded ornament should be documented with structured metadata that records not only its visual appearance but its interpretive meaning as reported by source communities, so that the resulting digital archive functions as an interpretive resource rather than a purely geometric one. Applied consistently, this framework would allow the strong technical precedents already established in Dong HBIM automation and African mosque-documentation databases to be extended toward fuller semiotic completeness, and would provide a shared methodological reference point for future comparative digital-heritage work across both regions.

10. Conclusion

This paper has argued that the drum-tower architecture of the Guizhou Dong and the vernacular architectures of Dogon, Ndebele, and related African traditions, despite arising from unrelated cultural and material histories, share a fundamental characteristic relevant to heritage preservation: both encode complex social and cosmological meaning into built form through spatial syntax, structural grammar, and applied ornament, and both transmit that meaning primarily through oral and embodied practice rather than written record. Comparative semiotic analysis shows

that the specific register carrying the greatest communicative weight differs between traditions — structural joinery in the Dong case, painted ornament and communal ritual maintenance in the African cases examined — but the underlying vulnerability is the same: digital documentation focused narrowly on geometric accuracy can preserve a structure's outward form while allowing its meaning to disappear along with the last generation of practitioners who understood it. The Decoding Dong project's integration of reality capture with oral-history recording offers a partial model for addressing this risk, and this paper's proposed four-component framework — geometric capture, paired oral documentation, integrated settlement-scale relational data, and structured symbolic metadata — is offered as a transferable methodology applicable to both the Guizhou Dong context and the diverse African vernacular traditions considered here. Future research should test this framework through original fieldwork combining digital capture with structured ethnographic interviewing in both regions, and should examine comparable cases in other orally transmitted vernacular traditions worldwide to assess the broader generalisability of the semiotic vulnerabilities identified in this study.

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