A Phygital Approach in Architecture for Preserving Dong Minority's Crafting Heritage

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This study explores the integration of physical and digital realms ("phygital") in architectural practice, focusing on preserving the intangible cultural heritage of the Dong minority in China amidst modernization and diaspora challenges. Utilizing Extended Reality (XR) technologies, including Augmented Reality (AR) glasses and Electromyography (EMG) wristbands, the study proposes a virtual crafting space that replicates traditional Dong crafting activities (e.g., wood carving, weaving, and jewellery making) to bridge physical distances within the Dong diaspora. This approach not only facilitates the participation of diaspora members in their ancestral crafting practices but also plays a crucial role in preserving their cultural heritage. The study demonstrates the potential of phygital methodologies to revolutionize architectural education and practice by merging traditional craftsmanship with digital innovation, thereby enhancing creative expression and contributing to the conservation of cultural heritage.

Keywords: *Phygital heritage, XR, virtual crafting, ethnic minority, heritage conservation*

INTRODUCTION

In an era marked by rapid digital transformation, the concept of "phygital", a blend of the physical and digital realms, has become increasingly significant in architectural practice, particularly in the preservation of cultural heritage. This study explores a phygital approach within the context of the Dong Villages in China, proposing a design that utilizes virtual crafting to bridge distances and preserve the cultural heritage of the Dong minority.

The Dong minority, renowned for their unique cultural practices and traditional craftsmanship, faces significant challenges due to modernization and diaspora migration. Traditional crafting skills and cultural practices are at risk of distinction as younger generations migrate to urban areas, leading to a potential loss of cultural identity and heritage. To address these challenges, this study aims to integrate Extended Reality (XR) technologies with traditional Dong crafting practices. By developing a virtual crafting space, this study intends to create an environment where members of the Dong diaspora can engage in and contribute to their ancestral practices, thus preserving their cultural heritage and reinforcing their sense of community.

Focusing on the Dong minority villages in China, particularly Zhao Xin Dong Village, the largest Dong village known for its balance between tourism and cultural preservation, this research explores the use of XR technologies, including Augmented Reality (AR) glasses and Electromyography (EMG) wristbands. These technologies aim to create an immersive crafting experience that replicates traditional Dong activities. The anticipated outcomes of this study include the creation and implementation of a virtual crafting space, increased participation of the Dong diaspora in traditional crafting activities, and the preservation and

revitalization of Dong cultural heritage. Additionally, this project seeks to enhance global awareness and appreciation of Dong crafts.

By merging traditional craftsmanship with digital technology, this research aims to revolutionize architectural practice through the integration of XR technologies. This phygital approach creates a virtual crafting space for real-time traditional Dong crafting activities, addressing the crises of cultural heritage endangerment and identity erosion among the Dong diaspora. This immersive platform ensures the intangible cultural assets of the Dong minority are not only preserved but also flourish in the digital age.

BACKGROUND

This study is structured around two principal components. Initially, it focuses on examining the cultural heritage of the Dong minority. Subsequently, it introduces a phygital approach that leverages XR technologies to aid in the conservation and revitalization of this heritage.

Dong culture

The Dong minority, one of the 56 ethnic groups in China, is highlighted for their traditional handcrafting practices, which persist despite the widespread adoption of digital technologies. This ethnic group is geographically situated at the confluence of Guizhou, Hunan, and Guangxi provinces in Southwestern China (Li *et al*, 2019, p. 614). Over many centuries, the Dong minority, known for their village gathering, has developed a unique cultural identity. A prominent feature of Dong culture is its unique architecture, notably the drum tower and 'Wind and Rain Bridges.' These structures are not just examples of exceptional woodworking but also play a crucial role in the communal life and social cohesion of the Dong villages.

The drum tower, emblematic of Dong villages, is constructed at the village's heart without the use of nails or rivets, showcasing an advanced understanding of woodworking. This multi-storey architecture is typically surrounded by a square, as shown in Figure 1, which becomes a hub for community engagement, including crafting, meetings, festivals, and other public gatherings, thus reinforcing the communal fabric of Dong society (UNESCO, 2013). The symbolic significance of the drum tower extends beyond its architectural ingenuity, embodying the Dong community's collective identity, kinship bonds, and societal values. As articulated by Shi et al (2012), the drum tower's prominence in Dong villages symbolizes a potent centripetal force, fostering regional recognition and national cohesion.

The spatial organization of Dong villages further reflects their communal ethos, with a hierarchical layout centred around the drum tower. Surrounding houses are constructed around the drum tower, while the 'Wind and Rain Bridges,' located at the village's periphery, serve as gateways into the community.

In addition to architecture, the Dong minority is also renowned for their traditional crafts, including embroidery, cross-stitching, silver ornaments, wood carving, and the creation of Dong garments, all of which carry cultural value and are transmitted across generations. The craftmanship of Dong is usually meticulous, and precise, and often follows a ceremonial approach. Take the crafting of Dong cloth as an example, it takes more than 30 steps to turn cotton into Dong fabric (Yang, 2023).

Cotton harvested from Dong farmland is cleaned and woven into fabric (Figure 2). Dong women prepare dye from indigo plants and lime water, applying it to the fabric multiple times until achieving the desired colour depth. Subsequently, a mixture of persimmon peels, chestnut shells, and Ardisia crenata is used for further dyeing, producing a deep blue hue with rosy highlights. The fabric is then dried, folded, and treated with egg white, followed by repeated mallet beating over two weeks to enhance its sheen. The final step involves starching the fabric with cattle skin glue to enhance durability and colourfastness. The fabric's value

increases with its shine, reflecting the craftsmanship and effort invested.

Figure 1
Drum Tower
(Source: University of Edinburgh Confucius Institute for Scotland, n.d.)

Figure 2
Dong women weaving fabric, photo by Wang (2023)

The crafting tools used in these processes, including hammer, chisel, needle, and loom etc., are themselves artifacts of cultural heritage.

It's common to see that Dong people gather and craft together under drum tower. That is the manifestation of the core of Dong people's community life and ritual, the synchrony, that people sitting or standing together, and doing the same thing at the same time. This is also expressed in the Dong Grand Song, a form of polyphonic folk singing recognized by UNESCO in 2009 as part of the Intangible Cultural Heritage of Humanity. Performed a cappella, it underscores a belief prevalent among the Dong people: 'rice nourishes the body, songs nourish the soul'. With no traditional written language, the Dong transmit their cultural legacy and knowledge through music. The Grand Songs, taught by experienced singers to choirs, are central to community events held at the drum tower, playing a key role in preserving Dong ethnic identity and heritage. This musical tradition, essential for ceremonies and festivals, allows the community to share emotions and stories, reflecting their commitment to unity and synchronicity.

However, due to the gradual acceleration of human modernization and the in-depth implementation of China's reform and opening-up policy, the Dong minority is facing the comprehensive impact of modern culture, foreign culture and market economy. This impact is evident in the assimilation of their traditional culture and alterations to the spatial structure of their villages. The challenge of preserving and promoting traditional culture amid the intersection of tradition and modernization is a central issue facing the development of traditional Dong villages. Geographical isolation, infrastructural limitations, and socioeconomic underdevelopment have historically preserved the distinct cultural identity of the Dong people through a long history of accumulation. However, this same isolation has left Dong culture vulnerable to external influences, made worse by a general lack of awareness among residents about the importance of protecting their cultural heritage. This lack of awareness leads to an uncritical acceptance of modern culture, resulting in the gradual assimilation of traditional practices (Shi, 2012, p. 2322).

The migration of younger generations to urban areas exacerbates the situation, as traditional crafting skills and cultural practices risk disappearing without successors. Furthermore, among the Dong diaspora, there is a growing concern over the loss of identity. Encounters with Dong cultural materials often lead to revelations about their disconnection from their heritage; many realize they do not know the Dong language, songs, dances, crafting techniques, or traditional attire. This situation highlights a dual crisis: the endangerment of cultural heritage and the erosion of identity among the Dong diaspora.

Phygital Heritage

The transition from Cultural Heritage to Digital Heritage represents a vital shift in how communities preserve, document, and access knowledge,

providing a foundation for integrating physical and digital realms. As noted by Luigini and Panciroli (2018), and further discussed by Lo Turco and Giovannini (2020, p. 1), this evolution is marked by the initial challenges and opportunities brought forth by digitization processes, including the introduction of a culture of transparency in knowledge description. The rapid advancement of digital technologies has facilitated the representation of heritage information through dynamic and interactive formats such as websites, smartphone applications, and virtual or augmented reality worlds (Nofal, Reffat, and Vande Moere, 2017, p. 221).

Within this context, the concept of 'phygital' blends the physical and digital realms, enhancing the value and meaning of cultural artifacts and practices. This term, conceptualized to highlight the integration of everyday objects with their environments through autonomous information gathering and performance adaptation, extends beyond simple complementarity to a mutually reinforcing relationship between the physical and digital layers (Nofal, Reffat, and Vande Moere, 2017, p. 221; Lo Turco and Giovannini, 2020, p. 3) Originally used in marketing to describe strategies that bridge e-commerce tools with physical stores, "phygital" strategies aim to create immersive real-world experiences where digital actions can trigger physical reactions, and conversely, physical action can result in a digital reaction. This involves transforming the physical world into an information system by embedding objects with machine-readable traces or sensors for communication through digital interfaces (Nofal, Reffat, and Vande Moere, 2017, p. 221).

The applicability of phygital concepts extends beyond the realm of marketing and retail. Diverse fields such as education, gaming, and tourism have begun to recognize the benefits of phygital approaches. For instance, the use of phygital maps (Figure 3) combines the tangible benefits of paper-based atlases, like ease of navigation and the tactile sensation of flipping through pages, with the dynamic capabilities of digital media, offering access to a wide array of constantly updated audio and visual content.

Building upon these applications, the concept of "Phygital Heritage" emerges as a promising area of exploration. This concept revolves around presenting heritage information through an integrated mix of physical and digital mediums. By incorporating digital tools into the exploration of cultural artifacts, environments, or activities, Phygital Heritage aims to enrich the cultural learning experience, making stories and historical insights more engaging and accessible. This integration not only adds depth to the digital experience but also makes the heritage more interactive and immediate, bridging the gap between static resources and dynamic exploration (Nofal, Reffat, and Vande Moere, 2017, p. 221).

Museums globally are initiating the incorporation of AR applications which facilitate visitors to engage with displays in creative manners (Figure 4), for instance, superimposing digital data onto tangible artifacts or recreating past scenes for users to investigate. Within the realm of archaeology, the digital restoration of ancient sites provides virtual excursions, allowing users to deeply engage with historical settings that might otherwise be out of reach. These examples underscore the vast potential of phygital applications in making heritage more engaging and comprehensible.

Figure 3
Phygital map (Nofal, Reffat, and Vande Moere, 2017, p. 222)

Figure 4
Digital model on website of museum (Lo Turco and Giovannini, 2020, p. 4)

Despite advancements, current research on Phygital Heritage often remains superficial, focusing on digital archives with limited interaction and narrative depth. This approach tends to position users as outsiders, merely observing rather than truly engaging with cultural artifacts. This study aims to fill this gap by proposing an immersive phygital experience centered on the Dong diaspora, enabling real-time participation in traditional crafting activities. By leveraging XR technologies, the project aims to enable real-time crafting sessions within a virtual representation of the crafting space in Dong village, allowing users to use physical tools and hand movements to create crafts in a digital environment, regardless of geographical distance.

CRAFTING SPACE AND ITS DIGITAL TWIN

This study aims to explore the integration of traditional crafting practices with XR technology within the Dong minority by building a physical crafting space in Zhao Xin Dong Village (Figure 5), Guizhou, known as the "NO.1 Dong Village." This location, the largest Dong minority village in China, is characterized by its successful balance between tourism and the preservation of local traditions. Despite modern influences, the community has maintained its cultural practices, with older residents and tourism workers often performing traditional activities for visitors. However, the pandemic has disrupted this balance, compelling many villagers to move to cities for employment, leaving a gap in cultural transmission and participation among the younger generation and diaspora.

To mitigate these challenges, the proposed crafting space, depicted in Figure 7, consists of a seven-story wooden structure designed to reflect the drum tower's communal and architectural significance. The crafting space will incorporate both physical and digital elements, offering round crafting tables for local use and a digital twin platform for global engagement. This phygital approach aims to reconnect the Dong diaspora with their heritage, allowing them to participate in crafting activities in real-time with villagers. The study endeavors to bridge geographical distances, revitalize traditional crafts, and enhance the community's sense of identity and belonging amidst modern challenges and the impacts of the pandemic.

Crafting table

The central feature of the crafting space will be its round crafting table (Figure 6), inspired by the Dong minority's traditional sun pattern. This design, using circular shapes, symbolizes the continuity and prosperity of life and culture. While functioning as a practical space for crafting activities, the table also embodies the cultural essence of the drum tower. With the integration of XR technology, the physical crafting table gains a digital twin (Figure 8), creating a phygital workspace. This innovation not only connects the Dong community with its global diaspora but also narrows the physical distance between them.

At this table, villagers can engage in traditional crafting, with the added option of collaborating with distant members of the diaspora on various projects such as wood carving, weaving, making silver ornaments, designing buildings, and even village planning, all around this communal table.

Figure 5
Site plan of Zhao Xin Dong Village with integrated physical crafting space

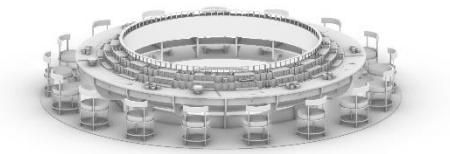

Figure 6
Crafting table

Figure 7
7-story wooden structure of crafting space

Figure 8
Digital twin of crafting space and crafting table

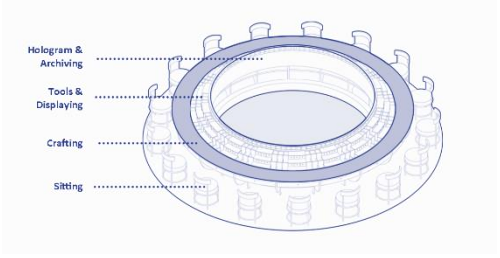

Figure 9
4 functional rings of crafting table

The crafting table is designed with four concentric rings (Figure 9): the sitting ring, the crafting ring, the tools and display ring, and the hologram and archive ring. The tools and hologram rings are designed to rotate like a compass, facilitating easy selection of tools and navigating the interface. This feature allows for more precise crafting and design work, an essential aspect when incorporating elements like Fengshui into their creations.

PHYGITAL METHODOLOGY

Individuals can either physically attend the crafting space when in the village or access its digital version through XR platforms, regardless of their global location. This segment will outline how the diaspora can interact with the digital twin of the crafting space. It aims to clarify the dynamics of phygital interactions within the studio and describe the process of engaging in virtual crafting activities.

The setup of XR environment

In the phygital crafting space, a seamless integration of the physical and virtual worlds is achieved through the employment of two wearable devices: AR glasses and EMG wristbands (Figure 10).

AR glasses serve as the cornerstone of this immersive experience. It will overlay digital information onto the real world, enhancing the user's reality with virtual details. Equipped with sensors and trackers, AR glasses is able to automatically track the user's hand movements and recognize the physical tools being used. This capability ensures that activities traditionally confined to the physical environment can now be replicated with certain accuracy in the virtual domain.

The second essential device, the EMG wristband, enhances this experience by utilizing sensors to measure the electrical activity produced by muscles during movement. This allows for a more nuanced and precise interaction with virtual objects and tools, enabling users to craft with a level of detail and finesse that was previously unattainable.

Together, these devices not only bridge the gap between the physical and virtual worlds but also expand the possibilities of crafting.

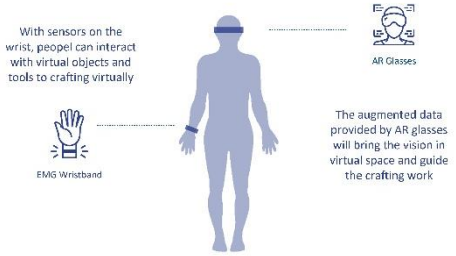

Figure 10
AR glasses and EMG wristband

Phygital interaction

Exploring the potential of virtual crafting unveils two scenarios in the crafting space, emphasizing the innovative ways in which technology can preserve and enhance cultural practices. The first scenario focuses on seminars and tutorials between individuals. For example, a Dong woman, present in the physical crafting space, can instruct her daughter in embroidery techniques despite her daughter's physical absence, facilitated through access to a digital twin of the studio. This mode of operation not only maintains but strengthens familial and cultural ties across distances.

The second scenario addresses communal meetings and collaborative work essential for village planning, decision-making, and remote presentations. This collective mode enables diaspora members to participate in significant community events from afar, thereby sustaining their ethnic identity, continuing heritage practices, and reinforcing a sense of community belonging despite geographical separation.

Virtual crafting distinguishes itself through remote access and the unique experience of virtual togetherness (Figure 11). It introduces the flexibility to manipulate scale within the virtual environment. For example, users can zoom out a building to a manageable scale, allowing them to hold and examine the digital model in their hand, or zoom in on a necklace for detailed crafting. This capability overcomes physical limitations and could herald a new design methodology that leverages the virtual realm's expansiveness and adaptability (Figure 12).

The crafts, crafting tools, and the digital site model of the village will be kept and achieved on the table, which forms a shared crafting experience (Figure 13). This will bring an additional significance to this virtual gathering, people are devoted to the community, and these moments will eventually be commemorated.

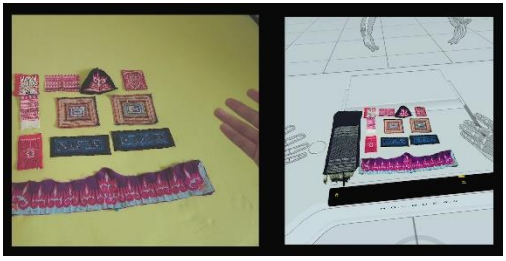

Figure 11
Separated diaspora can join in the crafting space remotely

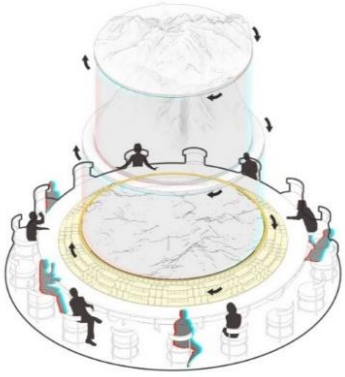

Figure 12
Physical craftsmanship can be replicated and scanned in the digital twin

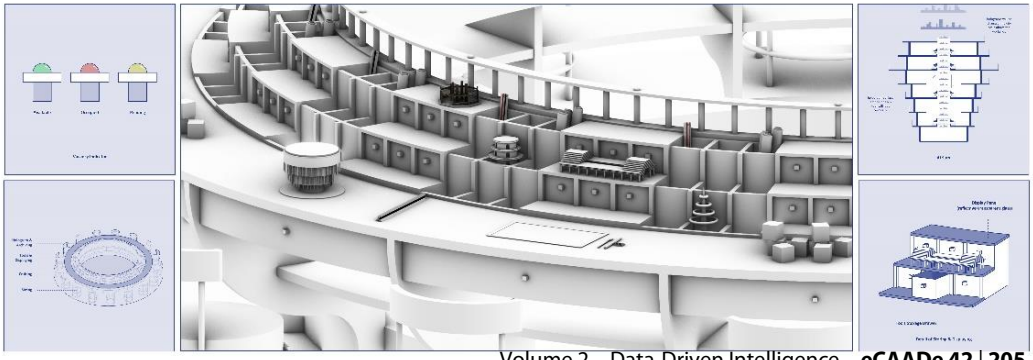

Figure 13
Details of the crafting table

DISCUSSION AND FUTURE WORK

This study introduces a phygital approach to significantly impact cultural heritage preservation, community engagement, and the broader field of heritage conservation. By merging XR technologies with physical experiences in the crafting space, it aims to connect the Dong minority with their diaspora, enabling them to actively participate in and contribute to their crafting traditions from afar. This innovative approach not only ensures the preservation of the Dong minority's intangible cultural heritage but also provides a dynamic platform for the continuation and development of their traditional crafts. It opens up avenues for these cultural practices to gain wider exposure, reaching a global audience and enhancing appreciation and understanding of Dong's heritage.

The core of this study is the commitment to preserving the intricate crafting heritage of the Dong minority, which faces threats from modernization and the fragmentation caused by diaspora migration. The phygital platform serves as a vital tool in documenting and revitalizing traditional crafting techniques, ensuring these practices are passed down to future generations. Moreover, this initiative plays a crucial role in fostering community engagement. By bridging geographical distances, it creates a sense of belonging and identity among the Dong people, reinforcing communal ties and facilitating the transmission of cultural values and practices.

Furthermore, the implications of this study extend beyond the Dong community, offering a scalable and adaptable model for cultural heritage conservation worldwide. With the integration of XR, the phygital approach enriches traditional craftmanship by enabling it to be taught remotely and online across the globe. This method facilitates a technology-driven democratisation of skills, ensuring that invaluable artisan techniques can be shared and preserved more widely than ever before (Goepel and Crolla, 2021). The framework proposed in this study, thus, presents a versatile solution that can be customized to suit various cultural contexts, potentially revolutionizing the way intangible cultural heritages are preserved and promoted globally. Through this study, a pathway is forged for diaspora communities to regain a sense of ethnic identity and community belonging, underscoring the universal significance of preserving cultural heritage in an increasingly digital world.

This study will also introduce a novel design methodology to the architectural industry through the phygital approach, blending the physical and digital realms to revolutionize architectural design, collaboration, and education.

In the architectural industry, the phygital approach enables architects to experiment with and visualize building designs in unprecedented ways (Rankohi and Waugh, 2013). By employing digital tools for rapid prototyping, 3D modelling, and immersive environments where designs can be tested and iterated with ease. The phygital method supports a sculptural approach to form-finding, allowing architect to craft and refine the physical shape of their design digitally before realizing them materially.

The phygital approach can also foster collaboration among architects, designers, and clients, enhance inclusivity and participation in the design and planning processes (Gillespie, Qin and Aish, 2021). By leveraging digital platforms for shared design activities, stakeholders can contribute to the design process from remote locations, enhancing project presentation, communication, and bringing diverse perspectives into the design process, crucial for projects spanning diverse geographical locations, such as urban design (Figure 14). Stakeholders can manipulate elements within a digital site model, offering a dynamic and interactive design process.

Figure 14
Remote meeting of urban design (Microsoft, 2021)

Moreover, the phygital approach will also bring implications for architectural education. It merges traditional craftsmanship with modern technology, enabling students to transcend physical constraints during the conceptual phase and apply their designs across various contexts. This method prepares future architects with a holistic skill set, and blends creative freedom with practical application.

This study, while presenting a phygital approach to cultural heritage, acknowledges several limitations in its current conceptual stage.

A significant aspect yet to be fully developed involves the precise nature and functionality of the crafting tools and the crafts produced within this crafting space. Critical questions remain regarding whether these crafts will remain exclusively in digital format or if there will be mechanisms to materialize these creations into physical objects. Additionally, the potential marketplaces for these digital crafts need exploration, while there're potential of integrating these into the gaming and film industries. Furthermore, the dynamics of interaction between the Dong minority within the physical crafting space and the diaspora engaging through digital twin need more clarification. Specifically, the modes and effectiveness of communication between these two groups warrant further exploration to ensure a cohesive and productive crafting experience.

This study also presents several technological challenges that must be addressed. Integrating the physical and digital worlds demands significant advancements in computer science, electronics, and physical design. One of the primary concerns is the accuracy of current hand-tracking technologies. Inaccurate hand-tracking can lead to ineffective interactions between users and virtual objects within the XR environment. This limitation can disrupt the immersive experience and hinder the practicality of virtual crafting. While enhancing hardware could solve the accuracy issue, the high costs associated with advanced hand-tracking technologies may not be feasible for individual users. However, pooling resources at a community level could make the investment more attainable, allowing for a collective approach to achieving the desired precision in virtual environments. Moreover, the XR platforms' capacity to support multiple users simultaneously can be constrained by current internet bandwidth and infrastructure. This limitation poses a significant challenge, especially for engaging a large diaspora in real-time crafting activities, potentially limiting participation and the sense of communal engagement crucial for cultural preservation efforts.

The subsequent phase of this research will concentrate on refining the phygital approach for the preservation of cultural heritage within the Dong community, aiming to achieve a seamless integration of physical and digital realms. The forthcoming work will encompass a thorough development of crafting tools and their resultant crafts, ensuring a tangible interaction with cultural artifacts. Moreover, optimizing the interaction dynamics between participants in the physical and digital crafting spaces will be critical. This entails addressing the technological challenges identified, such as improving hand-tracking accuracy and expanding the XR platform's user capacity, will be paramount to support broader community engagement.

CONCLUSION

This study explores a phygital approach that integrates physical craftsmanship with digital XR technology to preserve and promote the crafting traditions of the Dong minority. By developing a phygital crafting space, this research provides a dynamic platform for the Dong community and its global diaspora to engage in traditional practices, bridging geographical divides and fostering a deeper connection to cultural heritage.

Merging traditional craftsmanship with modern XR technologies ensures the preservation and revitalization of the Dong minority's intangible cultural heritage. This phygital approach enhances the participation of the Dong diaspora, strengthening their cultural identity and community bonds.

Furthermore, this research offers a scalable model for cultural heritage conservation worldwide. The integration of XR technologies democratizes traditional crafts, allowing for broader dissemination and appreciation. The phygital approach also presents significant implications for architecture, education, and community engagement, fostering collaboration and enhancing architectural education.

In conclusion, this study highlights the importance of preserving cultural heritage in the increasingly digital world. By providing a solution to the challenges faced by the Dong minority, it sets a paradigm for similar efforts in other cultural contexts, ensuring that traditional practices flourish alongside modern advancements.

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