

Augmented reality teaching material design for brocade patterns from the perspective of digital humanities: A case study of the *Mysterious Xilankapu*

Abstract

The Tujia ethnic group's traditional brocade Xilankapu encapsulates wisdom, values, and beliefs rooted in their productive and daily lives. This textile heritage serves as a high-quality pedagogical resource. To address the challenges of digital transformation, this study adopts a Digital Humanities perspective to design Augmented Reality teaching materials for Xilankapu. It proposes a systematic framework for AR-based pattern education and validates its pedagogical effectiveness through empirical design practices. Specifically, the design contains a paper-based textbook and Augmented Reality digital resources, of which, the Augmented Reality digital resources include the reconstruction of the 3D scenes of the Tujia ethnic group, the video of the dynamic renditions of four patterns, and the animation of the 3D model of the loom, which are developed using the smartphone-based Unity 3D+Vuforia technical solution, and the corresponding usability tests are conducted. This study confirms the value of Augmented Reality technology in teaching material design and pattern innovation while providing a digital innovation case for the Tujia brocade. The findings offer significant contributions to academic discourse and practical applications in cultural heritage preservation.

Keywords: digital humanities, brocade patterns, augmented reality, teaching material design, xilankapu

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Introduction

Patterns, as ornamental motifs adorning material surfaces, constitute a vital component of human aesthetic creation.¹ Traditional Chinese patterns, embodying the essence of Chinese culture, encapsulate unparalleled ethnic symbolism and creative spirit in global decorative history. These culturally condensed artifacts serve as exceptional pedagogical resources. Modern Chinese pattern education traces its origins to early 20th-century design pedagogy, extending from higher education to primary and secondary curricula. However, current pattern transmission and education face challenges of homogenized content and monotonous instructional materials, hindering students' aesthetic appreciation and necessitating pedagogical innovation.

Xilankapu, a traditional brocade of the Tujia ethnic group,² derives its name from the Tujia language meaning "flower-covered bedding". Functioning as quilts, blankets, and ritual textiles, it permeates the Tujia life cycle from birth to funerary rites, crystallizing millennia of wisdom, values, and beliefs. Constrained by weaving techniques, Xilankapu predominantly features geometric abstractions, eschewing realism through structured repetitions of symmetrical motifs. Its compositional principles employ continuous bilateral symmetry, diamond-based quadrilateral repetition like Yanzi Hu, as shown in Figure 1, as well as those formed through horizontal or vertical bilateral symmetry, and unidirectional repetition, such as Mabi Hua, as shown in Figure 2. Xilankapu is woven using an ancient waist-tensioned inclined loom, its main components include twelve parts. The weaving process is complex and labor-intensive, entirely manual. Xilankapu is woven on waist-tensioned looms using methods such as continuous base warp, base weft, discontinuous weft, and floral insertion. During weaving, the warp is separated into three layers—

upper, middle, and lower—to facilitate diverse patterns, as shown in Figure 3.

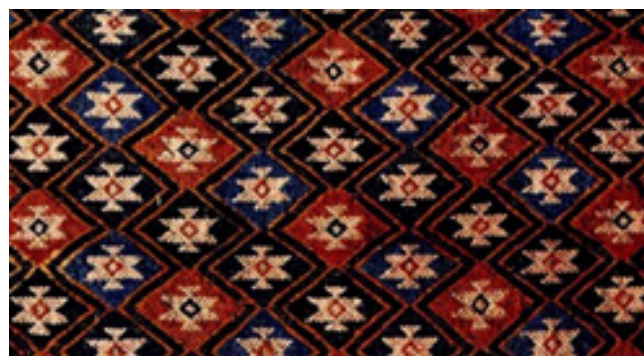


Figure 1 Xilankapu –Yanzihua.



Figure 2 Xilankapu –Mabihua.

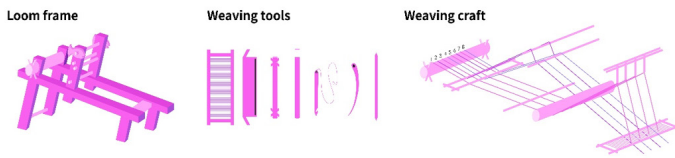


Figure 3 Xilankapu's Handcraft.

This textile heritage demonstrates multidimensional educational value through formal, technical, cultural, and innovative dimensions. First of all, Xilankapu's formal characteristics—abstraction, repetition, order, and ornamentation—serve as foundational elements for learning contemporary visual arts and graphic design, fostering students' aesthetic perception and enhancing their sensitivity to formal beauty. Secondly, studying handcraft helps students understand the relationship between materials and artistic expression, appreciate ancient Chinese handcraft ingenuity, and cultivate respect for handicrafts. Thirdly, Engaging with its cultural connotations enables students to comprehend Tujia livelihood practices, aspirations for communal well-being, and the vitality of folk traditions. This fosters respect for cultural diversity and cultivates informed perspectives on ethnic heritage. Fourthly, Xilankapu is a recreation of nature by the Tujia people. It can guide students to engage in artistic creation based on its stylistic features, fostering their creativity in transforming forms and patterns.

Confronting digitalization challenges, traditional brocade craftsmanship requires innovative preservation strategies. Digital Humanities, evolving from humanities computing, emerges as an interdisciplinary methodology leveraging computational technologies to reconstruct cultural research across breadth and depth. As a pivotal component of this framework, Augmented Reality (AR) technology offers unique advantages including virtual-physical integration, multimodal interaction, Free Viewpoint, and mobile accessibility, enabling immersive, participatory, and contextualized pattern education. Enhancing pattern pedagogy not only cultivates specialized design talents but also elevates public aesthetic literacy, fostering sustainable cultural development.

This study adopts a Digital Humanities approach to investigate AR teaching material design centered on Xilankapu. Through systematic analysis of the brocade's knowledge architecture, four educational value domains are identified: formal, handicraft, cultural, and creative. The study systematically examines the constitutive elements of AR pattern teaching materials, developing an integrated pedagogical system that combines instructional frameworks, printed materials, and AR digital resources. The AR implementation employs 3D modeling technology to digitally reconstruct traditional weaving techniques and ecological contexts, complemented by animated planar videos that visually articulate pattern composition principles and design logic. This multimodal approach facilitates students' immersive engagement with pattern aesthetics. The research demonstrates AR's effectiveness in transforming pattern education through digital means while advancing innovative approaches for cultural pattern preservation. These findings offer substantial reference value for expanding AR applications in design pedagogy and heritage conservation.

Related works

The establishment of China's pattern studies system owes much to pioneering art educators such as Lei Guiyuan, Chen Zhifo, and Pang Xunqin. Lei Guiyuan, a foundational figure in modern Chinese pattern studies, systematically developed pedagogical frameworks through works like *Foundations of Pattern Design* and *Preliminary*

Explorations of Chinese Pattern Techniques. He emphasized patterns as integral components of design, prioritizing geometric configurations, structural laws, and holistic integration of form, color, and composition. Chen Zhifo advocated for patterns' efficacy in childhood art education, proposing in *ABC of Pattern Methods* a quadripartite analytical framework: aesthetics, functionality, craftsmanship, and natural inspiration. Despite these theoretical advancements, research on pattern education for primary and secondary schools remains scarce.

Scholarly investigations of Xilankapu have been advanced through works like Tian Shunxin's *Historical and Pattern Analysis of Tujia Brocade* and Huang Qinkang's *Chinese Folk Textiles*, with Tian Ming's *Tujia Brocade* serving as a seminal reference. Studies by the Hunan Arts and Crafts Research Institute's *Formal Principles of Traditional Tujia Brocade Patterns* and Zuo Hanzhong's *Hunan Folk Art Compendium: Textiles* focus on artistic characteristics, while Peng Yi's *Applications of Tujia Brocade Patterns in Modern Design* explores contemporary adaptations.

Digital Humanities, an evolving conceptual domain, lacks a unified definition. Harvard scholar Peter K. Bol delineates four key distinctions from traditional humanities: digital resources, data infrastructure, computational data retrieval methods, and analytical visualization techniques.³ Jhon Unsworth's seven Digital Humanities characteristics—discovery, annotation, comparison, reference, sampling, illustration, and representation⁴—were later refined by Tobias Blanke into five primitives: discovery, collection, comparison, dissemination, and collaboration.⁵ Liu Wei et al. further systematized Digital Humanities technologies into six categories: digitization, data management, analytics, visualization, VR/AR, and machine learning.⁶

In applied contexts, AR provides actionable DH methodologies. MIT's Dan Roy highlights immersive technologies' capacity to enhance learner presence and empathy through multisensory engagement.⁷ Beijing Normal University's Cai Su has advanced AR's pedagogical potential across disciplines, while Jin Yiqiang's *AR Technology and Educational Applications* consolidates theoretical foundations for AR-enabled instruction.⁸

Notable AR teaching material prototypes include Mark Billingham's *Magic Book* from University of Washington⁹ and Fabio Zund's AR coloring books from Disney Research, which animate 2D drawings into 3D models.¹⁰ Phadung et al. applied the ADDIE model to develop AR-enhanced computer science e-books.¹¹ Nevertheless, AR's educational applications remain empirically driven, lacking mature theoretical frameworks for design principles and strategies.

In general, Current research landscapes reveal two prominent gaps: insufficient scholarly attention to pattern education in K-12 curricula, and constrained investigations into Tujia brocade that remain limited in both quantitative scope and analytical diversity.

To address these limitations, this study bridges these gaps by systematically deconstructing Xilankapu's knowledge framework and integrating digital humanities research paradigms with AR tools to develop an AR curriculum tailored for young learners. Technical implementations employ Blender for 3D reconstructions of ecological environment and loom, Adobe After Effects for animated pattern decomposition videos, and a smartphone-compatible AR system developed via Unity 3D with Vuforia integration. This pedagogical intervention seeks to achieve dual objectives: fostering students' aesthetic appreciation and digital competencies through immersive AR experiences, while providing a replicable model for technologically augmented heritage education.

Methodology

Fieldwork

Field studies were conducted in key Tujia brocade heritage regions, including Longshan County in Hunan Province, Qianjiang District, and Xiushan County in Chongqing Municipality. The investigations documented weaving techniques, craft production processes, and heritage transmission practices. Structured interviews were conducted with master artisans, supplemented by visits to local ethnic museums to collect primary research materials.

A design approach based on 3D scene reconstruction

The digital reconstruction of the scene in 3D can bring a strong sense of narrative and immersion. According to the geographic features, folk customs, myths and legends of the Tujia people, the symbolic elements are extracted, and the digital reconstruction of the 3D model using Blender can bring an immersive teaching experience to the students. The aesthetic tendency of children’s groups needs to be taken into account in this process, and a concise design style and bright colours are used to increase the fun.

A design approach based on dynamic video rendition

In order to effectively present the compositional rules of Silankappu patterns, four patterns, namely Yanzihua (Chinese:燕子花), Yangquehua (Chinese:阳雀花), Sishibagou (Chinese:四十八勾), Yeluhanhua (Chinese:野鹿含花), are selected for dynamic interpretation with the narrative structure of shape, order, colour and symbolism. This study uses Adobe after Effects to create a dynamic graphic video, so that students can see how a simple geometric figure gradually evolves into a complex Silankappu pattern, and thus understand the compositional rules and design logic.

A design approach based on model animation

In this study, Blender is used to produce the 3D model of the loom and its animation. The 3D model can show the structure of the Silankappu loom in 3D, and the model animation can clearly present the interspersed relationship of the various parts of the loom, which is convenient for the students to better understand the weaving process of Xilankapu.

Unity3D and vuforia application development

This study adopts the smartphone-based Unity 3D+Vuforia technical solution. Unity 3D is a cross-platform game development engine that can output multiple platform devices, which can effectively reduce the development cost and time, and supports scripting languages such as C#, JavaScript, etc., which is highly flexible and extensible. Vuforia is an AR development toolkit for creating various types of AR applications, which can be integrated with Unity 3D, Unreal Engine, and other mainstream 3D game engines, making it convenient for developers to quickly create AR applications.

Results

The Mysterious Xilankapu Paper-based textbook design

The textbook design process involves establishing visual standards across three key areas: color scheme, environmental and character design, and textbook layout.

First, regarding visual standards, analysis of Xilankapu’s Yangque Hua pattern reveals its characteristic use of black or dark blue backgrounds paired with high-saturation colors for strong

contrast. Accordingly, the primary color palette adopts blue-purple tones complemented by magenta, fluorescent green, and bright blue to maintain visual intensity. Specific color numbers are defined for implementation, as shown in Figure 4.

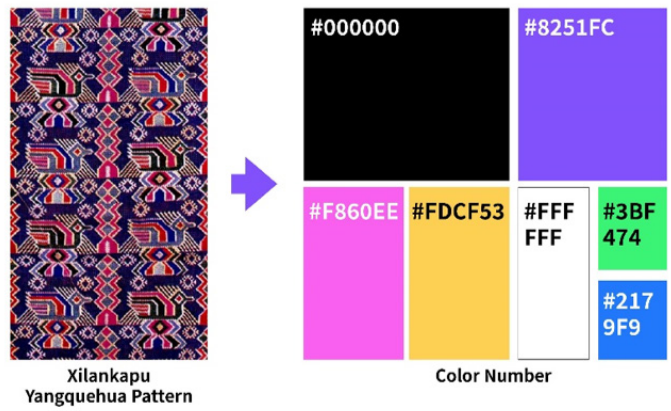


Figure 4 Specific color numbers.

Categorie	Reference Image	Character Design
Clothing	 women  men	 women  man

Figure 5 Character design.

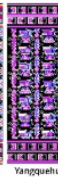
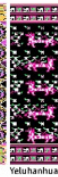
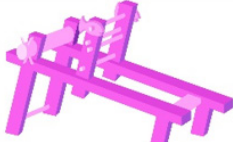
Categorie	Reference Image	Design of scenes and other elements
Stilt Houses		
Patterns	 Yanzihua  Yangquehua  Sishibagou  Yeluhanhua	 Yanzihua  Yangquehua  Sishibagou  Yeluhanhua
Loom		

Figure 6 The design of scenes and other elements.

Second, environmental and character design adopts a minimalist geometric style inspired by Xilankapu’s abstract patterns. Key elements including traditional costumes, architectural features, brocade motifs, and weaving tools are stylistically simplified and refined, as illustrated in the accompanying visual references.

Third, the printed textbook is organized into four chapters: “Chapter 1: Cultural Beauty,” “Chapter 2: Formal Beauty,” “Chapter 3: Handcraft Beauty,” and “Chapter 4: Creative Beauty.” The textbook employs an accordion-fold format to ensure content continuity, with content printed on both the front and back sides for user convenience. The reading sequence follows a left-to-right progression to align with standard pedagogical workflows, as shown in Figure 7 and Figure 8.

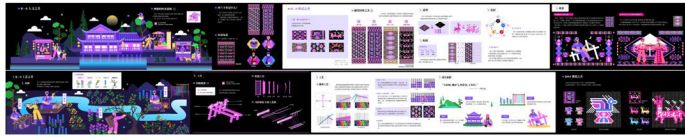


Figure 7 “Mysterious Xilankapu” textbook design.

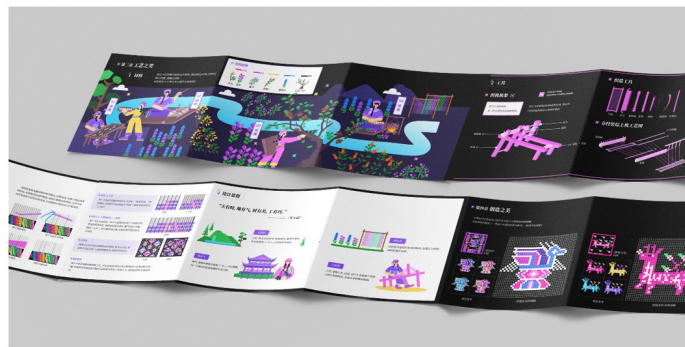


Figure 8 “Mysterious Xilankapu” Physical textbook.

Reconstruction of Tujia 3D scene model

Xilankapu is a representative of the culture of the Tujia people, and it cannot be created without the influence of the Tujia people’s own geographical environment and folk culture. In terms of the natural environment, the Youshui Valley in the Wuling Mountains of China is the gathering place of the Tujia people, with rolling hills, streams, and rivers. In terms of residential architecture, the Tujia people are characterized by stilt houses, with half of the houses standing on the water and half on the land, most of them are built on the mountains, and the houses are at a certain distance from the ground. In terms of folk culture, the Tujia people have been circulating the myth and legend of the Xilan girl. There was a girl named Xilan, who died unjustly because she learned how to weave the pattern of the white fruit flower, and then she was transformed into a bird, and the Xilan girl was thus transformed into a goddess of weaving the Tujia people.

According to the geographical environment, residential architecture, and folk culture, streams, mountains, forests, stilt houses, and birds are extracted as elements and modeled in Blender. In the process of modeling, it is necessary to consider the restoration of the elements, such as the architectural characteristics of the stilt, the main house of the stilt is built on the ground, and the compartments, except for one side which is connected to the main house on the ground, are overhanging on the other three sides and supported by the pillars. At the same time, it is also necessary to consider the style of the model to be consistent with the textbook, with simple and vivid shapes, and bright colors, giving people a sense of fun, as shown in Figure 9.

In the AR interactive experience, students can click on the “Natural Environment” or “Myths and Legends” buttons to learn more about the relevant details.

Dynamic video rendition of patterns

Xilankapu has a special artistic language and also embodies deep-rooted national cultural symbolism. In this study, four patterns,

namely, Yanzihua, Yangquehua, Sishibagou, and Yeluhanhua, are selected for the dynamic interpretation of the plane. In terms of styling, Xilankapu is characterized by geometric abstraction. In terms of the arrangement, the Yanzihua is characterized by a four-square continuous arrangement, the Yangquehua, and the Sishibagou are characterized by a two-square continuous arrangement, and the Yeluhanhua is characterized by a scattered arrangement. In terms of color, Xilankapu only inherits the styling, not the color, so the colors can be varied in many ways. In terms of symbolism, each pattern has its own connotation. Yanzihua represents good luck, Yangquehua represents new life, Sishibagou represents the happiness of husband and wife, and Yeluhanhua represents vitality.



Figure 9 Tujia 3D scene model.

Based on the above analysis, the narrative structure of tattoo dynamic video is “styling-arrangement-colour-meaning”, which starts from a single basic form, gradually expands into an orderly array of pattern, and then adds different colors, and finally presents pattern with meanings. Taking the dynamic video of the Yangquehua as an example, the video first presents the shape image of a single bird, then presents the bird combined with other elements to form a pattern combination, and then repeats the up and down arrangement changes to form a complete array of bird patterns, and then adds different colour changes, and finally presents the symbolism of the bird representing new life, as shown in Figure 10.

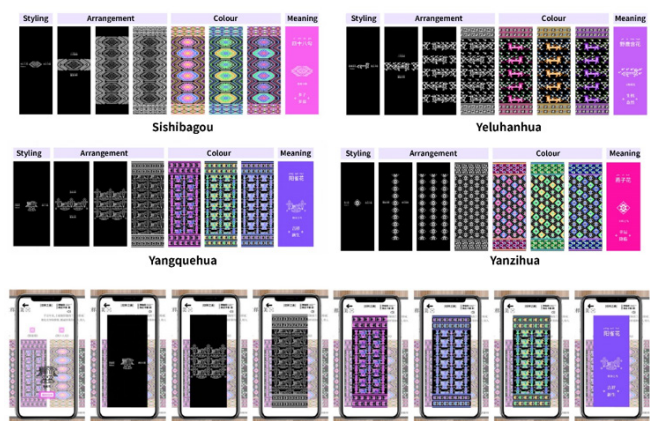


Figure 10 Four videos of different patterns.

In the AR experience, students scan the identification code in the textbook, and the “play animation” button appears, after clicking on it, they can see the corresponding video animation.

3D loom model animation

The loom used by Xilankapu consists of 12 components: roll plate, heddle rod, treadle, reed, shuttle, bobbin, picker, stretcher, fish-shaped weight, roller, tension belt, and reed knife. In this study, the loom is modeled and restored using Blender, and considering the consistency of the visual style, light pink and light purple are used as the main colors to bring a light-hearted feeling. At the same time, the combination animation of the loom was created, the frame appeared first, and then the parts such as the roller and fish-shaped weight appeared accordingly, and finally the whole loom was completed, and the animation was also done in Blender, as shown in Figure 11.



Figure 11 The 3D model animation of the loom.

In the AR experience, students scan the identification code and select the “play animation” button to see the combination of the loom animation, and when the combination is complete, they can hear the sound of weaving. Students can surround the loom and look at it from any angle, or pause to see the interspersed structure of the parts, thus promoting individual engagement.

Technology development and testing

This study adopts the technical solution of Unity 3D+Vuforia. After completing the design of AR digital resources, we upload the recognition object in the Vuforia developer portal, build the Unity scene, add the digital resources as sub-objects under the recognition object, write the code using C# script to achieve the basic functions, such as playback, and add the interaction logic to achieve the operation of clicking, dragging and so on.

Conducting usability testing on AR ensures optimal educational experiences during implementation. Three elementary students participated in the evaluation—one third-grader and two fifth-graders, as shown in Figure 12. Findings from user testing revealed the following conclusions:



Figure 12 Conducting usability testing.

The AR experience demonstrated high operational fluency, with students adapting seamlessly to the AR-based instructional format. No significant confusion was observed, and the interactive design effectively engaged learners, who exhibited strong enthusiasm and sustained interest in the content.

All students displayed marked curiosity and engagement with the 3D Tujia cultural scene. Feedback indicated that text density in the “Natural Environment” and “Mythological Legends” interfaces posed readability challenges for some participants, though the presence of audio narration mitigated this difficulty.

Students successfully learned Xilankapu’s pattern composition through animated videos and independently identified key loom components via 3D model observations.

The *Mysterious Xilankapu* AR teaching material integrates brocade patterns, educational innovation, and AR technology. It offers a methodological reference for the digital transformation of traditional craft-based curricula, opens new dimensions for the educational dissemination of ethnic culture, and demonstrates high potential for practical application and wider promotion. Furthermore, it provides a feasible pathway for the digital innovation of ethnic patterns.

Conclusion and future prospects

This study analyzed the knowledge system of Tujia brocade Xilankapu, distilling aesthetic content suitable for children’s learning while designing corresponding printed materials and AR digital resources. It explored the feasibility of AR-enhanced pattern education within the digital humanities framework, confirming AR’s value in both instructional design and pattern innovation. Through integrated theoretical and practical research, the following conclusions and outcomes were established:

Firstly, the research systematically organized theoretical foundations related to Xilankapu and AR teaching materials. By analyzing Xilankapu’s formal, technical, and cultural characteristics, it identified core design elements for AR educational resources from pedagogical content and media perspectives. This work addresses a gap in existing scholarship on integrating AR technologies with pattern education.

Secondly, the design implementation—exemplified by the “*Mysterious Xilankapu*” AR curriculum—demonstrated AR’s effectiveness in pattern education through developed lesson plans, printed textbooks, and digital AR resources. User evaluations confirmed the curriculum’s strong interactivity, engagement, and enjoyment, with students showing heightened interest in content. Participants adapted quickly to AR-enabled learning via smart devices, responded positively to the visual style, and effectively perceived Xilankapu’s aesthetic dimensions through formal, handcrafted, cultural, and creative lenses.

In summary, AR applications in pattern art education demonstrate significant potential. Future research could integrate artificial intelligence and mixed reality technologies to create more interactive and innovative learning experiences. Expanding AR applications to other artistic domains could develop additional aesthetically valuable curricula, fostering students’ aesthetic literacy and digital competencies. Such advancements would drive digital innovation in art education while enhancing instructional quality.

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Conflicts of interest

No potential conflict of interest was reported by the authors.

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