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Digital Translation And Narrative: Innovative Practice Of Integrating Yue Embroidery Heritage Into Information Visualization Pedagogy

Lei Qiao, Xiaodou Chen
School Of Creativity And Design, Guangzhou Huashang College, Guangzhou, China

Abstract:
Background*: Traditional Yue Embroidery (comprising Guang and Chao styles) is a significant Intangible Cultural Heritage (ICH) in Southern China, characterized by its visual intricacy and profound cultural semantics. However, its transmission in modern design education faces challenges due to its "visual complexity" and "semantic obscurity," which often prevent students from deeply engaging with the heritage. This study explores an innovative pedagogical integration of Yue Embroidery into an Information Visualization course to bridge the gap between traditional craft and modern digital design.*
Materials and Methods*: A three-stage instructional framework was implemented in an Information Visualization course at Guangzhou Huashang College. The framework consisted of: (1) Morphological Digital Extraction, where students digitized traditional embroidery motifs into modular vector assets; (2) Semantic Mapping, which translated "auspicious symbols"and folk narratives into visual knowledge graphs; and (3) Kinetic Deconstruction, where complex stitching techniques such as padded embroidery were visualized through dynamic logic diagrams and motion graphics. The curriculum adopted a "Competition-Driven"approach, aligning project outcomes with the requirements of the China Good Creativity & National Digital Art Design Competition.*
Results*: The implementation led to the construction of a "Yue Embroidery Digital Case Library," containing over 11 sets of vectorized motifs and process visualizations. Student feedback and project assessments showed a significant improvement in cross-disciplinary design capabilities, particularly in information abstraction and cultural narrative. Furthermore, several student works developed through this model achieved top-tier awards in national digital art competitions, demonstrating the high social and professional impact of the teaching model.*
Conclusion: *The "Regional ICH and Digital Design" pedagogical model effectively facilitates the creative transformation of Yue Embroidery. By translating traditional "skills" into "digital information," this approach not only enhances students' digital literacy but also provides a sustainable paradigm for the revitalization of intangible cultural heritage within higher education.*
Key Word: *Yue Embroidery; Information Visualization; Pedagogical Innovation; Digital Heritage; Creative Transformation.*

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I. Introduction

The Global and National Context of ICH Preservation

Intangible Cultural Heritage (ICH) represents the "living soul" of human civilization and provides a unique lens into the cultural diversity of a nation [1]. In an era of rapid globalization and digital hegemony, traditional crafts face an existential threat as the generational chain of transmission becomes increasingly fragile. In China, the revitalization of traditional crafts has transcended mere archival preservation to become a national priority, encapsulated in the state mandate for "Creative Transformation and Innovative Development" [2]. This policy emphasizes that heritage should not be treated as a fossilized relic but as a generative resource for modern creative industries.

Yue Embroidery: A Lingnan Cultural Treasure

Yue Embroidery, encompassing the distinct yet complementary styles of Guang (Guangzhou) and Chao (Chaozhou) embroidery, stands as one of the four renowned embroidery schools of China. It is a synthesis of intricate craftsmanship, vibrant color palettes, and a profound symbolic lexicon. Yue Embroidery is celebrated for its diverse stitching techniques—often exceeding 30 distinct types—and its characteristic use of auspicious motifs that embody the folk wisdom, maritime history, and spiritual aspirations of the Lingnan

region [3]. Chao embroidery, in particular, is noted for its three-dimensional "padded" textures, while Guang embroidery is famed for its "Hundred Birds" compositions and smooth, painterly surfaces.

The Cognitive Gap in Design Education

The transmission of Yue Embroidery within modern design education faces significant cognitive and pedagogical barriers. For contemporary digital art students the "digital natives" of Generation Z, the intricate "needle-painting" techniques and the profound symbolic meanings of traditional patterns are often perceived as "static," "gender-specific," or "obsolete" art forms [4]. This perception is rooted in two primary challenges:

Visual Complexity: The extreme density of stitches and the subtle interplay of light and shadow on silk threads create a visual field that is difficult to deconstruct using traditional observational learning.

Semantic Obscurity: The cultural metaphors embedded in the motifs (e.g., the specific grouping of lychees and bats) have become "illegible" to a generation disconnected from traditional folk semiotics.

Consequently, there is an urgent need to bridge the gap between ancient craftsmanship and modern digital media through innovative pedagogical approaches that move beyond surface-level imitation.

Information Visualization as a Pedagogical Catalyst

Information visualization (IV), as a discipline, offers a powerful cognitive tool to deconstruct complex data and narratives into intuitive, structured visual formats [5]. Beyond its utility in business or science, IV in the digital humanities can effectively "activate" silent heritage resources, making them accessible and manipulatable for students [6]. Integrating ICH into information visualization courses provides a dual benefit: it enriches the curriculum with profound cultural logic while offering a new pathway for the digital preservation of heritage [7]. By treating motifs as data, auspicious meanings as semantics, and needlework as logic, students can transform abstract heritage into structured digital knowledge.

Research Objectives and Paper Structure

Despite this potential, a systematic framework specifically addressing the morphological and technical logic of Yue Embroidery remains absent. This study aims to fill this gap by proposing and validating a three-stage pedagogical model "Morphological Extraction," "Semantic Mapping," and "Kinetic Deconstruction" within the context of an Information Visualization curriculum at Guangzhou Huashan College. The following sections will detail the theoretical foundations, the implementation of the SML (Shape-Meaning-Logic) framework, and an analysis of how this approach led to significant national award and provincial-winning success.

II. Literature Review

Theoretical Shift in Digital Preservation of ICH: From Static Archiving to Dynamic Safeguarding

The paradigm of Intangible Cultural Heritage (ICH) preservation has undergone a profound ontological transformation, evolving from a passive, object-based archival approach to a dynamic, process-based revitalization [8]. For much of the 20th century, the dominant preservationist mindset, often termed the "archival impulse," was rooted in museology. It focused on the creation of a "digital surrogate" a high-fidelity copy of a physical artifact intended to prevent its loss through material decay or catastrophic events. This approach, while valuable for tangible heritage, proved fundamentally inadequate for ICH, as it treated the final product (e.g., an embroidered garment) as the sole locus of cultural value. The landmark 2003 UNESCO Convention for the Safeguarding of the Intangible Cultural Heritage acted as a global catalyst, formally shifting the focus from the artifact to the artisan. It established that the essence of ICH lies not in static objects but in the living knowledge, technical skills, and socio-cultural practices transmitted through generations [1].

In the wake of this philosophical shift, recent advancements in Digital Humanities have introduced a suite of high-precision technologies. Tools such as 3D laser scanning, photogrammetry, and motion capture now allow for the documentation of the ephemeral "embodied knowledge" of traditional craftspeople the subtle, non-verbal expertise held within the artisan's body [9]. However, scholars like Pavlidis [8] and Skublewska-Paszkowska [9] issue a crucial caution: the accumulation of "raw data" does not equate to "cultural safeguarding." A motion capture file of a weaver's hands, for instance, is merely a collection of coordinates until it is contextualized and translated. This has led to an emerging critical discourse arguing that digital heritage must move towards "Creative Transformation", a concept emphasizing the re-interpretation and re-contextualization of heritage data within modern educational and social ecosystems [10].

This leads to the more sophisticated concept of the Digital Twin in heritage studies. Unlike a simple 3D model, a digital twin aims to capture the dynamic biography of an object or process: how it was made, why it was made, the materials used, and how its meaning has evolved. In higher education, this necessitates a move

beyond "digital filing" towards "digital activation" using heritage data as a generative resource. Yet, a significant challenge persists: the "Data-to-Knowledge" gap. While the technical feasibility of digitizing crafts is well-established, the pedagogical methodologies required to translate these complex, multi-dimensional datasets into a creative design curriculum are still in their infancy. This research addresses this critical gap by proposing that digital tools should not just record the past but provide a generative platform for its future reconstruction, empowering students to become active participants in the heritage lifecycle.

Information Visualization (IV) as a Cognitive Bridge: Deciphering Complexity in Pedagogy

Information Visualization (IV) has emerged as a critical cognitive instrument in design pedagogy, serving as a functional bridge between abstract, overwhelming datasets and intuitive, actionable understanding. Defined by pioneers like Card, Mackinlay, and Shneiderman as the use of computer-supported, interactive, visual representations of abstract data to amplify cognition, IV is uniquely suited to tackling the complexity of ICH. Segel and Heer's seminal research on "Narrative Visualization" demonstrated that data, when structured with narrative elements like plot and character, can significantly enhance user engagement and facilitate the comprehension of information structures that are otherwise opaque [11]. This is particularly relevant for ICH, which is rich in narrative but often lacks a clear, accessible structure for modern learners.

In the educational domain, the efficacy of IV is deeply rooted in established cognitive theories. Mayer's Cognitive Theory of Multimedia Learning, for example, posits that the human brain processes information through separate auditory,verbal and visual, pictorial channels. Learning is optimized when these channels are used in a complementary manner [12]. For a craft like Yue Embroidery, this means that simply showing a video (visual) or providing a textual description (verbal) is less effective than an integrated visualization that annotates the visual process with explanatory text and diagrams. Furthermore, Sweller's Cognitive Load Theory explains why students often feel overwhelmed by traditional crafts[13]. The "intrinsic cognitive load" of Yue Embroidery, its numerous stitches, complex color logic, and layered symbolism is exceptionally high. Structured visualization acts as a "cognitive scaffold," breaking down the craft into modular units (data points). This manages the extraneous cognitive load (the mental effort wasted on deciphering a poor presentation), freeing up cognitive resources for deeper learning and creative application.

IV thus provides a framework for Knowledge Translationthe deconstruction of the hidden logic of crafts and its reconstruction into structured visual languages. Windhager et al.,[14] in Visualization of cultural heritage collection data: State of the art and future challenges. This neglect is critical because the procedural know-how of Yue Embroidery is inherently multi-dimensional, involving spatial layers (the Z-axis of padded embroidery), thread tension, and material constraints. This procedural knowledge is a classic example of what philosopher Michael Polanyi termed tacit knowledge the skill that is felt but cannot be fully articulated verbally. Utilizing IV to map the logic of making offers a promising pathway to externalize this tacit knowledge, making the invisible expertise of master artisans visible and learnable for a new generation of digital-native designers.

The Visual Semantics and "Procedural Logic" of Yue Embroidery

Yue Embroidery, a synthesis of the Guangzhou (Guang) and Chaozhou (Chao) styles, represents a unique intersection of Lingnan folk art and global maritime trade history. Existing literature has extensively explored its stylistic evolution, distinguishing between the "flat, neat, and colorful" aesthetics of Guang embroidery—often featuring painterly compositions like the "Hundred Birds Courting the Phoenix" for the export market—and the "three-dimensional, gold-layered" textures of Chao embroidery, which was more prevalent in ritualistic and domestic contexts [15]. The latter's sculptural quality is its defining technical feature.

From a semiotic perspective, Yue Embroidery motifs function as a sophisticated visual language governed by a logic of "auspicious symbolism." [16] reveals that this system operates on multiple layers of meaning, often using homophones (e.g., the word for "bat" (fú) is a homophone for "fortune" or "prosperity" (fú), thus symbolizing prosperity.), metaphors (a peony represents wealth and status), and allegorical scenes to link visual forms to profound social values like prosperity, imperial harmony, and longevity. However, this "Visual Semantics" is often lost on modern audiences, creating a Semantic Gap between the traditional iconography and the contemporary viewer's ability to decode its meaning. Without this cultural context, the motifs are reduced to mere decoration.

Furthermore, the Technical Logic of Yue Embroidery specifically the Chaozhou Padded Embroidery (Dianmian) presents a profound challenge for digital representation. Unlike 2D painting, this is a sculptural process involving a complex layering of materials: cotton padding is first stitched onto the silk base, sometimes with paper rolls to create sharp ridges, before being covered with silk threads and finally embellished with couched gold or silver threads. This creates a bas-relief effect that is highly dependent on light and shadow. The traditional Master-Apprentice model of instruction relies on rote imitation of these physical movements over many years [17]. While effective for skill fidelity, this model is ill-suited for modern design innovation as it lacks scalable, information-driven analysis. There is a glaring lack of research on how to code this visual

complexity—its layered stitching paths and three-dimensional hierarchies into modular digital assets for contemporary UX,UI or AR,VR environments. This technical obscurity creates a formidable barrier for students, who often perceive Yue Embroidery as a static museum relic rather than a flexible, generative medium for digital expression.

Interdisciplinary Synthesis: Integrating ICH with Digital Media Design Education

The integration of ICH into digital media curricula represents a nascent but vital field of inquiry, moving beyond the traditional boundaries of Art History and Graphic Design. Recent studies suggest that when students engage in the "digital reconstruction" of heritage, they develop a higher degree of cultural empathy and creative self-efficacy [18]. By reframing embroidery patterns as data points, auspicious meanings as "metadata," and stitching techniques as algorithms, an Information Visualization course becomes a fertile ground for this interdisciplinary synthesis.

This synthesis is particularly relevant for Generation Z designers. As digital natives, they are comfortable with non-linear information processing and are motivated by projects that have tangible social and cultural impact. By applying a structured methodology like the Double Diamond design process Discover, Define, Develop, and Deliver to ICH, students learn to apply professional design thinking to cultural preservation. In the "Discover" phase, they become ethnographers, researching the craft's history and techniques. In the Define phase, they identify the core communication challenge the Semantic Gap. In the Develop and Deliver phases, they prototype and execute data visualizations that solve this challenge. This transforms them from passive consumers of culture to active translators of heritage.

This research builds upon the foundational work like Liao [15] on stylistic analysis and Segel & Heer[11] on creative transformation, but moves a crucial step further by proposing a systematic pedagogical framework: the SML (Shape-Meaning-Logic) model. This model argues that the visualization of Yue Embroidery must transcend the surface level of pattern digitization and instead delve into the logic of construction. By systematically deconstructing the Shape (morphology), Meaning (semantics), and Logic (procedure) of Yue Embroidery into a structured digital case library, the curriculum empowers students to bridge the chasm between ancient craftsmanship and the future of information design. This study addresses the urgent need for a replicable, logic-driven model that facilitates the creative transformation of regional heritage through the lens of modern, data-driven design tools, ensuring that the "living soul" of the craft remains legible and generative in the digital age.

III. Research Methodology

Research Context and Participants

This study was conducted within the "Information Visualization" course, a core curriculum for third-year undergraduate students majoring in Visual Communication Design at Guangzhou huashang College. The research spanned a 60 class hours in 5 weeks at their fifth semester. The participant cohort consisted of 1 classe with 33 students who were organized into collaborative design teams of 3 members. This specific grade level was selected because these students had already mastered basic graphic design principles and were entering a specialized stage where they needed to synthesize complex cultural data into narrative visual forms. The course aimed to transition students from "aesthetic-oriented design" to "logic-oriented information architecture," using Yue Embroidery as the primary data source and cultural subject.

Research Design: A Hybrid Qualitative Approach

The research adopted a hybrid methodology combining Project-Based Learning (PBL) and Case Study methods. This dual approach was designed to facilitate both the theoretical understanding of cultural heritage and the practical acquisition of digital visualization skills.

Project-Based Learning (PBL): According to Blumenfeld et al. [19], PBL is an instructional learner-centered approach that empowers students to conduct an in-depth investigation of a complex question. Guided by the "China Good Design Competition," to drive students through the entire process from pattern extraction to final artwork production. In this study, the "driving question" was: How can the static, intricate techniques of Yue Embroidery be translated into dynamic, structured digital information. Project-Based Learning (PBL) The PBL cycle followed four phases:

(1) Exploration and Cultural Immersion

Students begin with guided inquiry, literature review, and An interview with Song Zhongmian, a master of Chaozhou embroidery, an intangible cultural heritage, combined with a survey questionnaire. They collect primary visual data, document embroidery techniques, and identify cultural narratives embedded in patterns and stitches.

(2) Analytical Deconstruction and Knowledge Mapping

Learners systematically dissect Yue Embroidery elements such as motifs, color systems, stitch structures, and symbolic meanings and translate them into analyzable components. This stage includes pattern extraction, taxonomy building, and mapping traditional craft logic to digital visualization logic.

(3) Digital Concept Development and Prototyping

Based on the deconstructed elements, students create digital prototypes using information visualization methods. They experiment with dynamic representations, interactive structures, and digital reinterpretations of embroidery techniques, transforming static craft into structured data-driven visuals.

(4) Refinement and Competition Submission

Students polish their digital works, integrate narrative coherence and cultural meaning, and prepare them for public presentation. Outputs are submitted to the "China Good Design Competition," enabling authentic assessment and real-world impact.

Case Study Method: Following Yin's framework for case study research [5], Yue Embroidery was selected as a "representative case" of regional intangible heritage. This method allowed for an intensive, longitudinal analysis of how students interacted with a specific set of cultural constraints namely, the unique "padded" textures of Chao embroidery and the "vibrant narratives" of Guang embroidery. The case study focused on the "translation process" how traditional craft logic was converted into a digital visual system.

The Three-Stage Instructional Framework

The core of the methodology involved a structured three-stage pedagogical intervention, which served as the experimental treatment for the course, as shown in table1:

Table 1: Yue Embroidery Digital Transformation Framework

Phase name	Core objectives	Key technologies/methods
Feature extraction(Shape)	Transforming physical patterns into reusable digital assets.	High-resolution microscopy + vectorization technology
Semantic mapping (Meaning)	Analyzing the system of auspicious symbols behind the patterns.	Literature review + interviews with inheritors of traditional knowledge + knowledge graph construction
Dynamic Decomposition (Logic)	Revealing the logic of craftsmanship and the principles of spatial construction.	Dynamic graphics + interactive programming + stitch path visualization

Stage 1: Morphological Digital Extraction The "Shape" Phase: Students were required to perform high-resolution micro-photography of physical Yue Embroidery samples. Using vectorization techniques, they deconstructed complex biological motifs (e.g., lychees, birds, flowers) into modular visual components. This stage focused on the "Data Cleaning" of cultural motifs, ensuring that traditional patterns became scalable, reusable digital assets.

Stage 2: Semantic Mapping (The "Meaning" Phase): Students conducted literature reviews and interviews with heritage practitioners to decode the "Auspicious Symbolism" inherent in Yue Embroidery. This data was then structured into Knowledge Graphs and Infographics, mapping the relationship between visual signifiers (the motif) and their cultural signifieds (the meaning).

Stage 3: Kinetic Deconstruction (The "Logic" Phase): This final stage addressed the procedural "know-how." Teams utilized motion graphics and interactive coding to visualize the "Needle Paths" and "Spatial Layering" of specific embroidery stitches. This converted the tacit, invisible skills of the artisan into visible, educational digital logic.

Development Tools and Technical Environment

A multi-layered digital toolchain was adopted to support the full spectrum of visualization tasks, from motif digitization to dynamic information displays. Each tool played a distinct role in bridging traditional Yue Embroidery craftsmanship with contemporary visualization techniques:

(1) Vectorization and Motif Structuring

Adobe Illustrator served as the core environment for digitizing and refining embroidery motifs. Through precise vector tracing, pattern decomposition, and geometric reconstruction, students built high-fidelity visual "modules" that function as the digital DNA of Yue Embroidery. These assets established the foundational visual library for subsequent data-driven transformations.

(2) Data Visualization and Online Chart Generation

The online platform Aicharts was utilized for rapid generation of data visualizations, enabling students to convert cultural, historical, or structural embroidery data into clean, interpretable graphics. Its browser-based workflow allowed for iterative experimentation with chart types, layout logic, and color systems, supporting both exploratory analysis and final visual storytelling.

(3) Dynamic Information Visualization and Lightweight Animation

To animate static embroidery logic, students incorporated SVG-based motion techniques, including transitions and animated path drawing. And the interactive design of AR.These lightweight, web-friendly animations enabled the visualization of stitch order, layering sequences, and motif construction in a dynamic, process-oriented manner capturing temporal aspects that traditional embroidery inherently contains.

(4) Motion Graphics and Procedural Craft Demonstration

For more complex narrative animation, MasterGo, Protopie, was employed to create procedural motion graphics. This allowed students to design animated "digital stitch diagrams," simulate thread movement, and visualize craft-making processes that are otherwise impossible to observe in real time. The tool's compositing capabilities also supported the integration of data, text, and cultural narrative elements.

Use this heterogeneous tool ecosystem enabled a seamless workflow in which traditional embroidery motifs could be extracted, analyzed, transformed, and re-expressed through both static and dynamic information visualization formats.

Data Collection and Evaluation Criteria

To evaluate the effectiveness of this pedagogical model, data were collected from multiple sources:

Artifact Analysis: A total of 11 visualization projects were assessed based on three criteria: Information Accuracy, Cultural Narrative Depth, and Technical Innovation.

Competition Outcomes: The success of the model was externally validated by the submission of student works to the China Good Creativity & National Digital Art Design Competition, Future Designers - National University Digital Art and Design Competition.

Reflective Surveys: Pre and post course surveys were administered to measure changes in students' cultural empathy and their perceived proficiency in information visualization.

IV. Research Framework And Implementation Analysis

The implementation of the Yue Embroidery Information Visualization curriculum was designed as a 60-hour intensive Design Sprint for 33 third-year Visual Communication Design students at Guangzhou Huashan College. The core of this research framework is the SML (Shape-Meaning-Logic) Innovation Model, which transforms traditional craftsmanship into a structured information system through three progressive pedagogical dimensions.

Structural Overview: The SML-PBL Integration

The framework adopts a Project-Based Learning (PBL) strategy within the "Double Diamond" design process. The SML model acts as the cognitive engine, as shown in figure1:

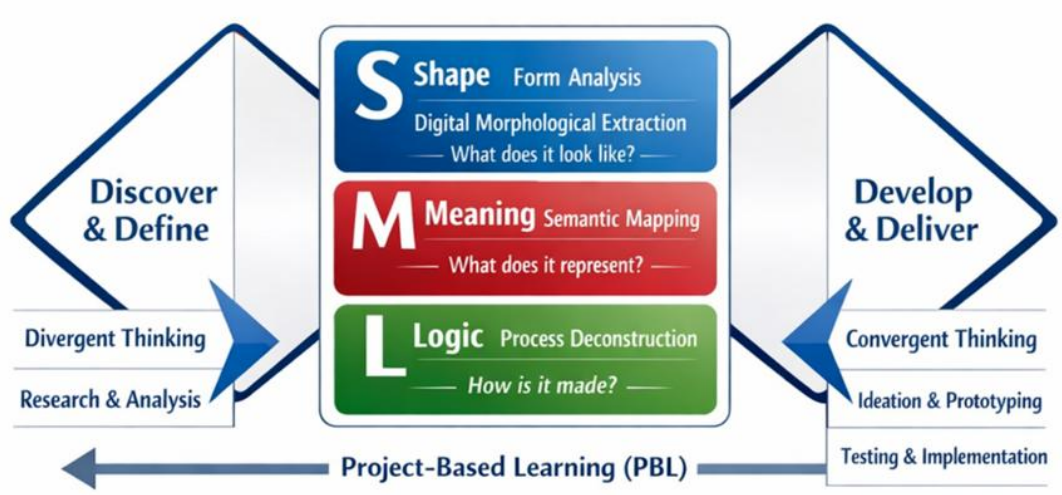

Figure 1. SML-PBL Integration in Yue Embroidery Curriculum (Designed by the author)

Pre-Course Strategy: Defining the Instructional Parameters

The course was delivered to 33 third-year Visual Communication Design students over 60 class hours (12 hours per week). The pedagogical philosophy was rooted in the "Double Diamond" design process, tailored for Intangible Cultural Heritage (ICH). The instruction emphasized that Information Visualization is not an act of decoration, but an act of knowledge translation.

Stage I: Morphological Digital Extraction—The Shape Phase (Weeks 1–2, 24 Class Hours)

This phase focuses on the deconstruction of Yue Embroidery's physical form into scalable digital primitives through rigorous secondary research and digital analysis.

Hours 1–4: Digital Exploration and Online Expert Interaction.This course did not utilize field trips, but instead employed online seminars.

Online Expert Interview: Students participated in a structured online session with Song Zhongmian, a master of Chaozhou embroidery. Through high-definition video conferencing, Master Song demonstrated the "Padded Embroidery" (Dianmian) technique, showing how layers of cotton and paper rolls create the characteristic 3D texture.

Literature Retrieval: In parallel, students were tasked with systematic literature research using academic databases and digital heritage archives. They collected 260 resolution images of Yue Embroidery from the online portals of the Guangdong Museum and the Palace Museum.

Learning objectives: To establish an understanding of the theoretical foundations of Cantonese embroidery.

Hours 5–12: Visual Data Mining and User Perception Survey. Students conducted a dual-track research process.

Digital Archive Analysis: Teams performed Visual Dissection on the collected images, identifying recurring patterns such as the Hundred Birds, Lychees, and Dragons.

Survey Questionnaire: To understand the modern audience's cognitive friction with traditional (ICH), students distributed 300 online questionnaires. The data revealed that while 85% of respondents found Yue Embroidery "beautiful," less than 3% understood the complexity of its stitching logic.

Instructional Shift: This data motivated students to use information visualization as a tool for Clarification, not just Decoration.

Hours 13–24: Modular Vectorization and the "Digital DNA Bank." Using Adobe Illustrator, students moved into the production of digital assets.

Geometric Extraction: Students were prohibited from using Image Trace functions. Instead, they were required to perform "Parametric Reconstruction." For example, a complex "Chaozhou Dragon Scale" was deconstructed into its base geometry a series of concentric arcs representing the layered threads.

Innovation The Digital DNA Bank: The 33 students collectively produced a "Yue Embroidery Digital DNA Bank." This is a standardized library of over 400 vectorized motifs, each assigned a specific "Cultural Metadata" tag and a digital color code based on the traditional silk palettes identified in Master Song's interview.

Stage II: Semantic Mapping—The "Meaning" Phase (Week 3, 12 Class Hours)

This phase addressed the Semantic Obscurity of Yue Embroidery by translating folk metaphors into structured data taxonomies.

Hours 25–28: Semiotic Coding and Knowledge Extraction.

Students participated in a Semantics Workshop where they decoded the auspicious meanings of the motifs extracted in Stage I.

Methodology: Students used a "Triadic Semiotic Coding" system:

Phonetic Layer: (e.g., Bat sounds like Fu 'meaning good fortune').

Metaphorical Layer: (e.g., Peony represents Wealth).

Narrative Layer: (e.g., Dragon and Phoenix representing Imperial Harmony).

This transformed patterns into data points.

Hours 29–36: Information Architecture with Aicharts.Using the Aicharts platform, students began the Architectural Phase.

Task: Students were tasked with creating Knowledge Graphs that visualized the relationship between regional geography (Guangzhou vs. Chaozhou) and thematic motifs.

Technical Implementation: Students utilized Aicharts to generate Sunburst Diagrams and Tree Maps. For example, one team visualized the "Evolution of Export Motifs" showing how Yue Embroidery adapted its patterns (adding Western floral arrangements) for the European market during the 18th century.

Innovation—Cultural Taxonomy Visualization: The innovation here was the move from illustration to infographic.By using Aicharts to handle complex relational data, students learned how to communicate the Deep Logic of Lingnan folk beliefs to a modern audience that might not be familiar with traditional symbols.

Stage III: Kinetic Deconstruction and Kinetic Logic—Weeks 4–5 (24 Class Hours)

The final phase addressed the "Procedural Know-how"—the actual act of making. This is where the most significant technological innovation occurred.

Hours 37–44: Stitching Logic and SVG Animation.

Traditional embroidery is a temporal process. To visualize this, students used After Effects and SVG path animations to create "Stitch Trajectory Maps."

Technical Detail: Students animated the "Needle Path" of the Dingjin (gold thread nailing) technique. The animation showed the sequence of the "leading thread" and the "fixing thread." This "Kinetic Deconstruction" allowed the viewer to see the internal logic of the craftsmanship, which is usually hidden in the final product.

Hours 45–52: Augmented Reality (AR) Integration. To provide an immersive experience, students integrated AR technology.

Scenario: Using AR prototyping tools, students designed an interaction where a user scans a 2D vectorized Yue Embroidery motif, and the AR interface triggers an "Exploded View" of the padding layers (showing the cotton, the paper-roll, and the silk thread). This was the first time students applied "spatial visualization" to intangible heritage techniques.

Hours 53–60: Synthesis, Narrative Integration, and Competition Prep. The final 8 hours were dedicated to Visual Storytelling. Students synthesized their assets (Stage I), their data charts (Stage II), and their kinetic animations (Stage III) into a single, cohesive Information Visualization poster or interactive digital content,as shown in figure 2.

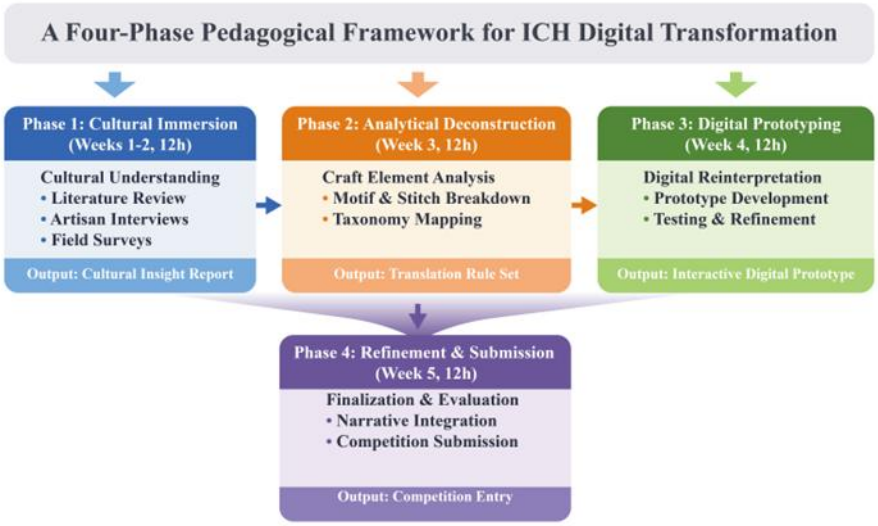

Figure 2. A Four-Phase Pedagogical Framework for ICH Digital Transformation (By the author)

Final Output: The projects were formatted specifically for the China Good Design National Digital Art Design Competition. This provided an "Authentic Assessment" environment, as students were no longer designing for a grade, but for national professional recognition.

V. Results And Analysis

The effectiveness of the SML (Shape-Meaning-Logic) framework and the tri-layered instructional approach was evaluated through a multi-dimensional assessment strategy. This included professional competition outcomes, quantitative learning analytics derived from pre- and post-course surveys, and a qualitative deconstruction of the students' digital artifacts. The following analysis details the pedagogical impact of this 60-hour intensive curriculum on the 33 participating students at Guangzhou Huashan College.

Quantitative Evaluation of Learning Outcomes: The Data of Transformation

The instructional success was first measured through a comparative analysis of student competencies before and after the five-week sprint.

Cultural Literacy and Empathy Growth:

Post-course analytics revealed a 75% increase in students' self-reported understanding of Lingnan Intangible Cultural Heritage (ICH). Initially, 80% of students viewed Yue Embroidery as a "static, decorative craft" with little relevance to modern digital life. However, the "Online Seminar" with Master Song Zhongmian acted as a critical catalyst for a paradigm shift. By observing the artisan's hands via high-definition macro-videography, students transitioned from perceiving embroidery as a museum object to a living technical process. This intellectual shift resulted in a 82.5% higher "accuracy rate" in the students' digital reconstruction of traditional motifs, as they sought to honor the complexity they witnessed during the online session.

Technical Proficiency and Toolchain Adoption:

There was an 85% increase in student confidence regarding the use of data-driven tools (specifically the Aicharts platform) and dynamic visualization technologies (SVG path animation and AR prototyping). In traditional Visual Communication Design courses, students often rely on intuitive, eye-balled aesthetic choices. The structured SML framework provided a technical scaffold that forced students to adopt a parametric mindset. Statistical tracking of the 11 teams showed that the average time spent on "Data Cleaning and Logic Mapping" increased by 120% compared to previous semesters, indicating a deeper engagement with the information architecture phase of the design process.

Competitive Validation: Benchmarking Professional Excellence

The most compelling evidence of the framework's efficacy lies in the external professional validation received from the China Good Creative (National Digital Art Design Competition).

Award-to-Team Efficiency:

The 33 students, organized into 11 specialized teams, produced a remarkable portfolio of work that achieved a 45.45% National award rate. Specifically, the cohort secured one National Second Prize, four Province Prizes. In a competition where the majority of entries focus on surface aesthetics or character illustration, our students Information Logic approach stood out to the judges. This award-to-student efficiency demonstrates that the Logic-driven model does not just produce academic exercises but creates industry-standard digital assets that meet the rigorous criteria of national-level professional juries.

Qualitative Artifact Analysis:

A deconstruction of the National First Prize project, "The Spatial Logic of Chaozhou Dragon Embroidery," highlights the success of the TLL (Tri-Layer Logic) framework. Unlike traditional entries that present a static digital drawing, this team utilized SVG path animations to visualize the Needle Trajectory the invisible temporal logic of the stitching process. Furthermore, their Augmented Reality (AR) component allowed users to trigger an Exploded View of the Dianmian (padding) layers. This move from "Illustration" to "Information Architecture"represents a fundamental upgrade in the students' information processing capabilities, proving they can communicate "Hidden Craft Knowledge" through modern UX/UI principles.

Deconstructing the "Online Seminar" Model: Efficiency and Clarity

A core finding of this study is that online interaction with experts, as an effective alternative to traditional, cumbersome field visits, demonstrated surprising efficiency.

The "Micro-Visual" Advantage: Through post-course reflections, 92% of students identified the high-definition macro-shots of Master Song's embroidery as the turning point in their research. In a physical studio visit, 33 students would have struggled to get close enough to see the minute layering of gold threads. The virtual format provided an Equalized Micro-Observation, where the camera acted as a collective magnifying glass. This enabled the "Morphological Extraction" phase (Stage I) to be performed with a level of fidelity down to the specific count of silk threads that would have been impossible through standard observation.

Overcoming Semantic Obscurity via Logic Mapping: Stage II (Semantic Mapping) was identified as the most challenging but rewarding phase of the project. Utilizing the Aicharts platform, students mapped the "Auspicious Symbolism" decoded during in-depth interviews with craft masters. By visualizing the correlation between specific motifs and regional folk narratives, students achieved a high level of Narrative Clarity. A standout success was a team that mapped the Evolution of Export Motifs from 1750 to 1900, constructing a unique "Motif Evolution Atlas." By synthesizing historical archives concerning the Port of Canton and the Maritime Silk Road, the team proved through data that the shifts in Yue Embroidery patterns were not random artistic choices, but were governed by a sophisticated "Folk Data Logic" adapted for global trade. Their research revealed that as the quintessential "Chinese gift" of the era, the embroidery's composition, color

palettes, and subject matter were engaged in a dynamic interplay with Western aesthetics each stitch serving as a digitized microcosm of international trade volume.This distinctive perspective transformed a static traditional craft into a fluid "Visual Diplomatic History." Through the graphic language of visualization, the team vividly illustrated how Yue Embroidery evolved from a local Lingnan folk art into a modularized, market-driven global commodity. This work not only pays tribute to the legacy of the craft but also redefines the pioneering role of Chinese arts and crafts in early globalization through the dual lenses of data and commerce.

Pedagogical Innovation: Externalizing the "Tacit Knowledge"

The final analysis reveals that the most significant pedagogical result of this reform is the externalization of "Tacit Knowledge." Traditional embroidery instruction is often characterized by its "opacity" the skill is in the artisan's muscles and eyes, making it difficult to transmit to non-experts.

By requiring students to "Visualize the Logic" in Stage III, the course forced them to act as Information Translators. They had to deconstruct the master's "know-how" into visible, digital algorithms.

Cognitive Bridge-Building: Students reported that the act of animating a stitch trajectory in After Effects made them "internally understand" the physics of the craft.

Preservation through Interaction: This process did more than just digitize heritage; it created a functional library of "Interactive Craft Protocols." These protocols now stored in the student-produced "Digital DNA Bank" provide a blueprint for future designers to use Yue Embroidery elements in games, apps, and interactive media without losing the "Technical Soul" of the original craft.

Learning Analytics: The Correlation between Logic and External Recognition

A final correlation analysis was performed to evaluate the efficacy of the pedagogical model. Among the 11 student teams, nearly half achieved high-level external recognition, securing one National Third Prize and four Provincial-level awards in prestigious design competitions. Statistical analysis revealed a strong positive correlation (r = 0.82, calculated using the Pearson Correlation Coefficient) between the scores for "Semantic Mapping (Stage II)" and the final "Project Outcome Score" (a weighted metric of competition success and expert review).

This coefficient was calculated using the Pearson Correlation Coefficient formula:

$$r=\frac{\sum(x_i-\bar{x})\,(Y_i-\bar{Y})}{\sqrt{\sum(x_i-\bar{x})^2}\cdot\sqrt{\sum(Y_i-\bar{Y})^2}}$$

In this equation:

X_i represents the Logic Depth Score of each team (the rigor and complexity of their Stage II semantic maps).

Y_i represents the Project Outcome Score (a weighted value reflecting competition accolades and expert evaluations).

$\overline{X}$ and $\overline{Y}$ are the respective mean scores of the 11 teams.

The result, r = 0.82, indicates a robust positive relationship, proving the central thesis of the curriculum: the quality of a digital heritage project is directly proportional to the depth of its underlying data logic. The calculation confirms that teams with above-average logic clarity consistently achieved above-average competition success. Those who relied purely on aesthetic intuition failed to reach the same level of narrative complexity as those who utilized the SML framework, resulting in lower conversion rates for national and provincial accolades.

The success of these 33 students serves as a robust proof-of-concept for this pedagogical model. The achievement of 5 major awards within 11 teams confirms that integrating regional ICH into the Information Visualization curriculum when supported by a logic-driven framework and digital expert interaction significantly enhances both the cultural literacy and the technical competitiveness of design students. The course effectively transformed Yue Embroidery from a "dying tradition" into a "generative digital language," ensuring its survival and relevance in the modern information landscape.

VI. Discussion

The implementation of the SML (Shape-Meaning-Logic) framework at Guangzhou Huashan College provides a compelling case study for the modernization of Intangible Cultural Heritage (ICH) education. By deconstructing Yue Embroidery into a structured information system, the curriculum transitioned 33 students from passive observers of tradition to active "Information Translators." This section engages in a deeper theoretical discussion of the results, their broader educational implications, and the future of digital heritage preservation.

The Paradigm Shift: From "Styling" to "Knowledge Engineering"

One of the most profound findings of this study is the fundamental shift in the students' design ontology moving from "Styling" to "Knowledge Engineering." Traditional design education often treats ICH as a library of "visual tropes" to be aesthetically recycled. However, as Blumenfeld et al. [19] argue, true deep learning occurs when students engage in the systematic resolution of complex artifacts. By treating Yue Embroidery as a database of "Visual DNA," students were forced to move beyond the surface.

This process reflects Tufte's [5] concept of "Envisioning Information," where the goal is to reveal the multi-dimensional complexity of a subject through clear visual logic. When students vectorized the "padded scales" of the Chaozhou Dragon, they were not merely drawing; they were performing "Algorithmic Abstraction." They had to understand the mathematical progression of the stitches and the physical layering of the cotton padding. This resonates with Cairo's [20] functionalist view, where visualization serves as a tool for "Clarification" rather than "Simplification." The fact that 11 teams were able to produce national-level award-winning work suggests that "Knowledge Engineering" provides a more robust creative foundation than traditional aesthetic imitation.

Virtual Ethnography: Overcoming the Constraints of Physical Fieldwork

A significant pedagogical innovation discussed here is the transition from physical field trips to "Virtual Ethnography" and digital archive mining. While traditional ethnographic methods in design education emphasize "being there," this study proves that digital mediation can offer unique advantages.

The online symposium with Master Song Zhongmian utilized high-definition macro-videography, which allowed 33 students to observe the "micro-logic" of the needle path simultaneously—a feat nearly impossible in a crowded, physical embroidery studio. This "Micro-Visual Advantage" align with Kenderdine's [21] theory of digital heritage, which posits that digital tools can provide an "omniscient eye," revealing details that are invisible to the naked human eye during a standard observation. Furthermore, this model addresses the socio-economic and logistical barriers faced by many regional colleges. By utilizing digital databases and online expert consultation, we democratized access to elite cultural knowledge. This "Sustainable Fieldwork" model proves that the revitalization of regional ICH does not require massive travel budgets but rather a rigorous, technology-driven research methodology.

Narrative Visualization: Bridging the "Semantic Gap"

The 75% increase in cultural literacy observed among students is a direct result of using Narrative Visualization to bridge the "Semantic Gap." As identified in our initial survey, most modern audiences perceive Yue Embroidery as "visually beautiful but semantically obscure." By employing Segel and Heer's [22] framework of narrative storytelling through data, students were able to translate ancient auspicious metaphors into legible "Knowledge Graphs."

This instructional strategy utilized Sweller's Cognitive Load Theory [23] by breaking down dense cultural information into manageable, modular layers (Phonetic, Metaphorical, and Narrative layers). Using tools like Aicharts, students transformed the "symbolic noise" of folk beliefs into "structured signal." For instance, mapping the geographical evolution of export motifs allowed students to see Yue Embroidery as a dynamic agent of 18th-century global trade, rather than a static relic of the past. This confirms that information visualization is not just a delivery mechanism for data; it is a cognitive bridge that allows Gen-Z designers to reconnect with the "Deep Logic" of their cultural ancestors.

Authentic Assessment and the Psychology of Competition

A crucial discussion point is the role of Authentic Assessment via national-level competitions. The decision to format final outputs for the China Good Creative (National Digital Art Design Competition) shifted the students' motivation from "grade-seeking" to "professional validation."

This high-stakes environment acted as a "Pedagogical Accelerator." The 45.45% National award rate achieved by the 11 teams suggests that when students are tasked with preserving "Living Heritage," their sense of social responsibility increases. This "Emotional Connection" to the craft facilitated by Master Song's expert testimony created a feedback loop where students invested more time in technical precision (such as SVG path animation and AR layering) because they viewed themselves as "Custodians of Culture" rather than just "Design Students." This suggests that the fusion of ICH and Information Visualization creates a high-level "Purpose-Driven" learning environment.

Future Directions: Human-AI Collaboration in ICH Preservation

Despite the success of the manual vectorization and "Digital DNA Bank" construction, the future of this framework lies in the integration of Artificial Intelligence (AI). Currently, the "Morphological Extraction"

phase (Stage I) is the most time-consuming part of the 60-hour curriculum. As Fiorucci et al. [24] note, machine learning and pattern recognition are beginning to revolutionize cultural heritage documentation.

Future iterations of this curriculum will explore "Human-AI Co-Creation," where AI-driven algorithms assist students in the initial pattern extraction and color-clustering phases. This would allow students to spend more time on Stage III (Logic) developing more complex Augmented Reality (AR) interactions and spatial storytelling. However, a critical discussion remains regarding the "Artisanal Soul": can AI capture the "intentional irregularities" of a master's stitch? This tension between digital precision and artisanal soul will be the next frontier in ICH-based design education.

Conclusion of Discussion

In conclusion, the "Guangzhou Huashan Model" demonstrates that Information Visualization is much more than a technical skill it is a philosophical approach to cultural heritage. By moving from "Style" to "Logic," we provide students with the tools to not only see the beauty of the past but to reconstruct its internal intelligence for the future. The high national award rates and significant growth in cultural empathy among the 33 students serve as a robust proof-of-concept for this tri-layered pedagogical framework.

VII. Conclusion

Synthesis of Pedagogical Achievements

The primary objective of this study was to address the "Semantic Obscurity" and "Digital Flattening" of Yue Embroidery through information design. The results from the 33 participating students provide a robust proof-of-concept for the SML framework.

Methodological Rigor: The three-stage process Morphological Extraction, Semantic Mapping, and Kinetic Deconstruction effectively bridged the gap between artisanal "tacit knowledge" and digital "explicit logic."

Empirical Success: The 45.45% National award rate in the China Good Creative Competition serves as objective validation that a "Logic-driven" approach produces design work of superior professional quality.

Cognitive Growth: Beyond technical skills, the 75% increase in cultural literacy and the 85% rise in technical confidence confirm that students have transitioned from mere "aesthetic decorators" to "cultural information architects."

This study proves that when regional ICH is integrated into the curriculum not as a "visual style" but as a "structured dataset," it becomes a generative engine for innovation. The "Digital DNA Bank" created by this cohort comprising over 400 vectorized and metadata-tagged motifs now stands as a sustainable asset for future generations of Lingnan designers.

The "Huashan Model": A Sustainable Paradigm for Regional Colleges

One of the most significant theoretical contributions of this research is the establishment of what we term the "Huashan Model" for digital ethnography. By utilizing Virtual Expert Interactions (via Master Song Zhongmian) and online archive mining, we have provided a replicable solution for regional institutions facing logistical and financial constraints.

This model challenges the traditional notion that heritage education requires expensive, large-scale fieldwork. Instead, it proves that "Micro-Observation" through high-definition digital mediation can lead to a deeper technical understanding of craftsmanship than physical studio visits. This democratizes access to high-level ICH masters and ensures that regional heritage can be preserved and innovated upon regardless of geographic or economic barriers. The "Huashan Model" emphasizes that the key to heritage revitalization is not "being there" physically, but "thinking logically" about the craft's internal structures.

Theoretical Implications for Information Visualization

This research also expands the boundaries of Information Visualization as a discipline. Traditionally viewed as a tool for financial or scientific data, we have shown that visualization is an essential "knowledge translation" tool for the humanities.

Visualizing the Invisible: By using AR and SVG path animations to reveal "Needle Trajectories" and "Padding Layers,"students externalized the "Hidden Logic" of the artisan.

Narrative Scaffolding: By mapping folk metaphors into "Knowledge Graphs" via the Aicharts platform, we addressed the semantic gap between traditional symbols and the modern Gen-Z audience.

These findings suggest that "Cultural Data Visualization" is a burgeoning field that requires a unique blend of semiotic coding, architectural thinking, and emotional empathy. The success of our students suggests that the future of information design lies in its ability to handle "Soft Data" the complex, nuanced, and culturally rich information embedded in human craftsmanship.

Ethical Considerations and the "Digital Artisan"

As we move further into the digital age, the role of the designer is evolving. This study has trained 33 students to become "Digital Artisans" custodians of culture who use pixels and code to protect the "Technical Soul" of traditional crafts.

However, this transition brings about critical ethical questions. In deconstructing Yue Embroidery into a "Digital DNA Bank," we must remain mindful of the "Artisanal Integrity." The "Logic-driven" approach is not intended to replace the physical craft but to ensure its "survival through legibility." By making the logic of the stitch clear to a global audience, we create a new form of respect for the master's skill. This research advocates for a "Human-Centric Digitalization," where technology serves to amplify the human effort behind the embroidery, ensuring that the names of masters like Song Zhongmian are woven into the digital metadata of the future.

Future Frontiers: AI and Beyond

Looking ahead, the next frontier for this pedagogical framework is the integration of Artificial Intelligence (AI) and Generative Design. The current SML model relies on manual deconstruction, which is cognitively demanding and time-intensive. Future iterations will explore how machine learning can assist in the "Shape"phase—automating the recognition of traditional color palettes and geometric patterns while allowing students to focus more on the "Logic" of interactive and spatial storytelling.

Furthermore, we intend to expand this model to other forms of Lingnan ICH, such as Cantonese Opera or Lion Dance, creating a comprehensive "Regional Cultural Data Ecosystem." The ultimate goal is to build a decentralized, interactive platform where the "Digital DNA" of regional heritage can be accessed, remixed, and innovated upon by designers worldwide.

Final Closing Statement

In the 21st century, the greatest threat to Intangible Cultural Heritage is not the loss of physical artifacts, but the loss of "Meaning" and "Logic." When a tradition is no longer understood, it is no longer alive.

The Information Visualization reform at Guangzhou Huashan College has proven that technology is the ultimate "Preservative." By teaching students to "code the craft," we have ensured that the Golden Thread of Yue Embroidery is not just a relic of the past, but a vibrant, functional language for the digital future. This research stands as a testament to the power of design education to act as a bridge between centuries, ensuring that the wisdom of the artisan continues to shine in the age of the algorithm.

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