# Generative Artificial Intelligence in the Safeguarding of Living Craft Intangible Cultural Heritage: Applications and Boundaries — A Case Study of the National ICH "Paper Stationery Processing Technique"

*Fenghai Wu*[1*], *Jing Liu*[2]

[1*]*Hefei Economics and Tourism School, Hefei, Anhui, 230011, China*
[2]*Anhui Duoyingxuan Calligraphy and Painting Supplies Co., Ltd., Chaohu, Anhui, 238076, China*

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ABSTRACT

Paper stationery processing technique is a national-level intangible cultural heritage (ICH) that embodies artisanal value and traditional literati aesthetics, yet it faces structural challenges including transmission discontinuity, fragile material carriers, dispersed craft resources and insufficient endogenous viability. Generative artificial intelligence (AI) opens a new technological pathway for the digital safeguarding of living craft ICH, but existing research has largely focused on image restoration and digital exhibition of tangible heritage, while micro-level case evidence and ethical boundary analysis for living craft ICH remain underdeveloped. Taking the national ICH "Paper Stationery Processing Technique" as its object, this study adopts a single-case study method and literature analysis to examine four application dimensions: rescue preservation, resource governance, assisted transmission and dissemination activation. It focuses on the "AIGC pattern generation–3D-printed mold–manual application" composite chain, assessing both its value for expanding paper stationery processes and its applicable boundaries. The study identifies structural risks of technological intervention: erosion of authenticity, ambiguous copyright attribution, weakening of craft subjectivity and the digital divide. Findings indicate that generative AI can significantly improve the efficiency of ICH archival construction and broaden cultural dissemination; 3D-printed molds can serve as a new craft intermediary for pattern processing. However, the legitimate application boundary is confined to the resource infrastructure layer and the tool-assistance layer, and must not intrude upon the epistemological layer of craft. Algorithms and digital molds can undertake externalizable technical tasks such as pattern conception, material retrieval and model formation, but cannot replace the embodied perception, situated judgment and manual practice that artisans develop through material engagement. Grounded in the principle of "bearer-led, technology-assisted", this paper proposes four

CONTACT:

[1]Author: 2546466032@qq.com

*Corresponding Author: 2546466032@qq.com

Note: Authors designated with "†" are recognised as co-first authors.

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ABSTRACT

governance strategies—tiered labeling, authorized training, practice priority and inclusive tools—and distils generalizable implications for the digital safeguarding of comparable living craft skills.

## 1.Introduction

Cultural digitalization has become a significant issue in global cultural heritage preservation. UNESCO's Recommendation on the Ethics of Artificial Intelligence establishes core ethical principles—transparency, fairness and human oversight—setting an ethical baseline for AI intervention in cultural heritage safeguarding. China's National Cultural Digitalization Strategy Outline explicitly calls for leveraging digital technologies to promote the creative transformation and innovative development of fine traditional Chinese culture. Against this backdrop, generative AI, with its technical advantages in image generation, knowledge extraction and interactive content production, has gradually entered the practice of intangible cultural heritage safeguarding.

Paper stationery processing technique is a representative category of traditional handmade paper art in China. It was inscribed on the national ICH list in 2008, with Anhui Duoyingxuan Calligraphy and Painting Supplies Co., Ltd. as the project's safeguarding unit. The technique encompasses dozens of complex procedures, including sizing, dyeing, gold-sprinkling, floating-color (liusha) and block-printed pattern application, embodying centuries of literati aesthetic wisdom and artisanal practice. Yet as a typical living craft ICH, the digital wave has not automatically dissolved its developmental predicaments: the aging of inheritors is pronounced, the traditional oral transmission model persists, and standardized craft archives remain insufficient; antique stationery, as organic artifacts, is highly susceptible to aging and deterioration, while conventional physical restoration is costly and operationally risky; historical pattern catalogues are scattered across multiple institutions, resulting in low efficiency in pattern retrieval and reuse; public awareness, particularly among younger demographics, remains limited, and the circle of transmission and dissemination is difficult to expand.

Existing research exhibits two notable gaps. First, most studies on generative AI's empowerment of cultural heritage focus on tangible heritage such as murals, stone carvings and ancient texts, addressing image restoration and digital reconstruction, while paying insufficient attention to living craft skills that combine material carriers, dynamic procedures and aesthetic creation. Second, existing studies tend to argue for the legitimacy of technological empowerment at a macro level or simply enumerate binary lists of opportunities and risks, rarely addressing the key question: what is the legitimate boundary for generative AI's intervention in living ICH? This boundary is not determined by the level of technological advancement but is rooted in the epistemological characteristics of the craft itself and the social realities of ICH transmission. Meanwhile, the technological combination of AIGC pattern generation and 3D-printed molds introduces a new craft intermediary for pattern-processing handicrafts such as paper stationery. This "AI generation–mold formation–manual execution" composite chain has not received adequate attention in ICH digitalization research, and its craft value and potential risks urgently require systematic assessment.

Accordingly, this paper takes the Duoyingxuan paper stationery processing technique as its analytical case and seeks to answer three core questions: What specific application scenarios can generative AI implement in paper stationery ICH safeguarding? Under what conditions does technological intervention enhance living transmission, and what insurmountable boundaries does it encounter? How can a governance pathway be constructed that balances technological efficiency with the bearer's subject position? Through in-depth case analysis, this paper aims to provide an analytical framework with both practical reference value and theoretical reflection for the digital safeguarding of craft-based ICH.

## 2. Literature review

### *2.1 Core consensus and unresolved issues in ICH digitalization*

The core proposition of ICH digitalization concerns how digital technologies can accomplish heritage rescue, preservation and dissemination without disrupting the essence of living transmission. Wang (2013) proposed that living transmission is the core essence of ICH safeguarding, and that digital means cannot directly

replace manual practice. Huang (2022) further noted that digital technologies can aggregate ICH resources and expand dissemination influence, but also bring risks including the erosion of cultural authenticity and excessive commercialization. International scholarship initially focused on standardized digital archiving and public participation mechanisms, with recent research shifting toward community cultural rights, data sovereignty and benefit-sharing. Overall, "technology as means, living transmission as core" has become a basic scholarly consensus, yet differentiated digitalization pathways for different ICH types—particularly the synergy between digital technology and manual practice in craft domains—require further investigation.

### *2.2 Generative AI and cultural heritage: from technical application to boundary reflection*

Research on generative AI in cultural heritage has expanded rapidly in recent years. Systematic reviews of ICH safeguarding indicate that generative adversarial networks (GANs) and diffusion models are the dominant technical approaches, applied primarily to pattern generation, style transfer, and image restoration. For tangible cultural heritage, studies focus on intelligent completion of artifact images and digital virtual exhibitions; for intangible cultural heritage, oral history organization, craft motion capture, and culturally creative assisted design have emerged as the primary areas of exploration. However, existing reviews note that most studies emphasize technical performance evaluation while lacking systematic analysis of the epistemological differences between algorithmic output and manual practice within living ICH. Generative models excel at producing visually plausible continuations but struggle to generate craft expressions rooted in specific artisanal contexts. This discrepancy has limited impact in static tangible heritage but constitutes a fundamental contradiction in living craft research.

Additive manufacturing, developing in parallel with generative AI, has also been gradually applied to handicrafts and heritage restoration. Existing studies mostly examine 3D printing for artifact replication, missing-component supplementation and tactile exhibition (Ballarin et al., 2023), with limited exploration of its potential as a craft intermediary embedded in living manual production workflows. When AIGC handles pattern generation, 3D printing produces molds, and artisans undertake subsequent manual procedures, technology is no longer confined to recording and display but becomes deeply embedded in the complete production chain. This shift poses new challenges to the definition of "handicraft", the diversified development of patterns, and the allocation of rights over patterns and molds, which Sections 4 and 5 address specifically.

### *2.3 The digitalization gap in paper stationery processing technique research*

Existing research on paper stationery falls into three main directions: craft history, transmission-status surveys and cultural-creative development. Craft history studies trace the development and technical characteristics of varieties such as Xue Tao stationery, floating-color stationery and gold-sprinkled stationery (Fan, 2018; Xu and Yi, 2022); transmission surveys focus on the practical survival difficulties of workshops such as Duoyingxuan; cultural-creative studies discuss contemporary transformation pathways for paper stationery cultural elements. However, systematic research combining generative AI with paper stationery craft safeguarding remains absent. This constitutes both the entry point of this paper and an indication that theoretical resources from adjacent fields must be drawn upon to construct an analytical framework.

## 3. Experiments and Results

### *3.1 Research design and case selection*

This paper adopts a single-case study method and literature analysis. Single-case research is suited to examining complex real-world phenomena and can meticulously reconstruct the internal logic and practical tensions of technology implementation in ICH contexts (Yin, 2018). Literature analysis is employed to review ICH safeguarding theory, generative AI ethical governance frameworks and existing paper stationery research, establishing a theoretical reference and comparative baseline for the case analysis.

The Duoyingxuan paper stationery processing technique was selected for three reasons. First, typical representativeness: Duoyingxuan is a core transmission entity for paper stationery processing technique, having restored multiple lost varieties including gold-and-silver printed stationery and hand-painted gold-traced powder-wax stationery, with a complete craft system. Second, existing digitalization foundation: the workshop has already conducted basic digitalization work such as antique stationery scanning and pattern archiving, providing realistic conditions for discussing AI implementation and avoiding purely theoretical speculation. Third, generalizability of predicaments: the challenges it faces—transmission discontinuity, resource dispersion and limited dissemination—are shared by numerous traditional craft ICH projects in China, giving the research conclusions transferable value.

Data for this study comprise three categories: public literature and policy documents, including ICH safeguarding policies, monographs on paper stationery craft and academic papers; public ICH archives, including official Duoyingxuan materials, national ICH application documents and inheritor interview records; and industry practice cases, namely publicly available outcomes of cultural heritage AI restoration projects and ICH digitalization initiatives. Multi-source data triangulation was employed to ensure analytical credibility.

*Table 1 Data* sources *and triangulation design*

| Data category | Specific contents | Function in analysis | Triangulation use |
|---|---|---|---|
| Public literature and policy documents | ICH safeguarding policies; paper stationery monographs; academic papers | Theoretical reference; policy baseline | Cross-check with archival and practice data |
| Public ICH archives | Duoyingxuan official materials; national ICH application documents; inheritor interview records | Case facts; craft procedure details | Verify craft claims against literature |
| Industry practice cases | Cultural heritage AI restoration projects; ICH digitalization outcomes | Comparative benchmark; feasibility evidence | Compare with workshop's digitalization foundation |

[Source: compiled by the authors.]

### *3.2 Application scenarios of generative AI in paper stationery ICH safeguarding*

Based on the practical needs of paper stationery processing technique transmission, generative AI applications are divided into four levels. A preliminary clarification is necessary: the level classification is not merely a functional categorization but also embodies a core analytical judgment: the closer an application is to the resource infrastructure layer, the stronger its technological legitimacy; the closer it approaches the craft ontological layer, the more pronounced technology's limitations become.

#### *3.2.1 Rescue preservation: virtual restoration of antique stationery and structuring of craft knowledge.*

The foremost challenge in paper stationery transmission is the fragility of physical carriers and the risk of losing artisans' tacit knowledge. Generative AI can produce reference restoration schemes for antique stationery

without touching the originals, facilitating the transformation of orally transmitted craft experience into structured digital archives. At the restoration level, traditional paper artifact restoration relies on manual mounting and supplementation, heavily dependent on the restorer's individual experience and involving irreversible operational risks. For the Qing dynasty damaged gold-sprinkled landscape stationery in Duoyingxuan's collection, diffusion models can be used for image restoration, learning pattern regularities and chromatic systems from contemporaneous analogous catalogues to generate virtual completion schemes for damaged areas. Such schemes are submitted to inheritors for evaluation and then serve as reference for physical restoration, reducing trial-and-error costs, with outcomes deposited in digital archives. It must be clarified, however, that virtual restoration drafts constitute referential reconstruction, not equivalent to the original's actual appearance; their status lies between documentary evidence and hypothetical image, and source information and confidence levels must be annotated. At the craft archiving level, procedures such as floating-color liquid-surface regulation and gold-sprinkling density rhythm are highly dependent on artisanal hand-feel, and purely textual records cannot fully capture craft details. Motion capture can collect inheritors' operational data, and generative models can decompose dynamic procedures into segmented demonstration animations; large language models can extract craft knowledge from oral historical materials to build a searchable craft knowledge base. The value of this application lies in stripping repetitive archival work from inheritors, allowing them to devote energy to irreplaceable craft teaching and manual practice, rather than pursuing algorithmic "understanding" of handicraft.

***3.2.2 Resource governance: intelligent recognition and semantic retrieval of stationery patterns.***

Historical stationery catalogues are scattered across collections, and retrieval inconvenience constrains craft teaching and creative design. Computer vision and generative models can perform element segmentation, pattern classification and style clustering on stationery images, annotating dynasty, technique and school labels to build a structured paper stationery pattern feature database, enabling "search stationery by text" and "search stationery by image" functions. Inheritors can input natural language or fragmentary stationery images to rapidly locate pattern resources dispersed across institutions. This level represents the application with the highest legitimacy for generative AI in paper stationery safeguarding. Its core value lies not in generating new content but in making existing heritage resources more accessible to the transmission community. The system does not produce finished stationery samples that replace manual work but reduces the cost for inheritors to obtain reference materials. Duoyingxuan has completed digital scanning of several hundred antique stationery sheets and, with intelligent annotation, has built a basic pattern database, achieving markedly improved retrieval efficiency compared with manual modes, serving craft teaching and design work.

*Table 2 Functional modules of the paper stationery pattern retrieval system*

| Module | Technical approach | Input | Output | Craft use |
|---|---|---|---|---|
| Element segmentation | Computer vision segmentation model | Scanned stationery image | Pattern elements with boundaries | Pattern decomposition for teaching |
| Pattern classification | CNN classifier | Segmented elements | Category labels (floral, landscape, geometric, etc.) | Organizing teaching materials |
| Style clustering | Unsupervised clustering | Element features | Style groups by dynasty/school | Comparative aesthetic analysis |
| Semantic annotation | Multimodal model + LLM | Image + textual description | Dynasty, technique, school tags | "Search by text" |
| Image retrieval | Feature matching | Fragmentary stationery image | Similar patterns across collections | "Search by image" |

[Source: compiled by the authors.]

***3.2.3 Assisted design and craft intermediary: from AIGC pattern generation to 3D-printed molds.***

Under the premise that inheritors define stylistic direction, craft constraints and cultural connotations, AI image generation models can rapidly output multiple design drafts, which inheritors then screen and modify before final manual production. For example, in reproducing and innovating Song dynasty floral stationery, AI can output multiple format schemes in a short time; inheritors select feasible versions for manual trial dyeing, compressing the preliminary conception cycle. In teaching scenarios, standardized stationery samples and procedure animations can serve as auxiliary teaching aids to help apprentices understand aesthetic characteristics and procedural logic. On this basis, the integration of AIGC and 3D printing further deepens technological intervention, forming an "AIGC pattern generation–3D-printed mold–manual application" composite chain: inheritors determine pattern style and craft requirements, AIGC outputs pattern schemes, screened schemes are vectorized and input into 3D printing equipment to produce physical molds for block-printed pattern application, embossing or localized sizing; artisans use the molds to complete printing, embossing and sizing procedures on handmade paper, with the finished product still relying on manual operation. For block-printed stationery samples, the practical value of this chain is evident: traditional woodblock engraving involves lengthy plate-making cycles and high modification costs; 3D-printed molds offer rapid formation and convenient iteration, creating conditions for small-batch, multi-variety stationery trial production, facilitating Duoyingxuan's craft restoration and innovation experiments, and enriching the technical means of

paper stationery processing.

At the same time, the chain's clear boundaries must be delineated. First, a mold is merely a tool, not equivalent to the craft itself. 3D-printed molds alter the pattern-formation stage, but printing pressure control, mold-paper surface conformity, pigment-binder concentration and timing rhythm still depend on the artisan's hand-feel and situated judgment; molds can only replicate the geometric shape of patterns and cannot reproduce the wood grain, knife-stroke depth and material traces formed by long-term use that are inherent to traditional woodblock engraving. Second, the standardization tendency of molds may compress the natural diversity of patterns. Traditional hand-engraved blocks naturally produce subtle variations; different batches of the same stationery sample carry natural variations introduced by handwork. 3D-printed molds derive from a single digital model, and repeated use systematically eliminates handmade variation characteristics. Third, the mold chain generates new attribution difficulties: the creative subjects and rights scopes of AIGC-generated patterns, modified digital models for printing and physical printed molds must be defined separately and cannot be lumped together as "AI-assisted design".

*Table 3 Value and boundary of the AIGC–3D printing mold chain*

| Dimension | Value | Boundary / risk | Governance response |
|---|---|---|---|
| Plate-making cycle | Rapid mold formation; low modification cost | Does not reproduce woodblock material traces | Use for trial production only |
| Pattern variation | Enables small-batch, multi-variety trials | Single digital source compresses handmade variation | Preserve traditional engraving as independent lineage |
| Craft process | Serves embossing, printing, localized sizing | Key procedures still depend on hand-feel | Retain manual operation after mold formation |
| Attribution | Separates pattern, model and mold | Rights of prompter, inheritor, platform, printer unclear | Layered authorization (pattern–model–mold) |
| Teaching | Convenient demonstration aid | May be mistaken for the whole craft | Practice-first sequence; critical discussion object |

[Source: compiled by the authors.]

In summary, this paper positions this chain as an assisted design and craft intermediary layer, situated between the resource infrastructure layer and the craft ontological layer. Its application rationality depends on whether it serves the inheritor's craft judgment and manual practice rather than replacing them. In practice, 3D-printed molds are suitable for craft trial production, effect verification, teaching demonstration and small-batch innovation; they should not directly replace traditional engraving as a conventional scaled-production means; key procedures after mold formation must retain manual operation, and finished products must be subject to the

inheritor's craft evaluation and acceptance.

***3.2.4 Dissemination activation: immersive content and public awareness expansion.***

Paper stationery culture has long been confined to niche circles, and traditional dissemination channels have limited reach. Digital humans and large language models can enable low-cost production of lightweight new-media content such as popular-science short videos and virtual workshop experiences, reaching younger audiences and expanding public awareness. Such applications hold practical value for broadening the audience base, but also carry the risk of superficial cultural representation: if dissemination only showcases the visual spectacle of finished products while obscuring material debugging and trial-and-error failures, the public gains only stylistic impressions of paper stationery rather than complete craft cognition. Dissemination content should therefore prioritize presenting the production process itself—including binder ratio debugging, gold-sprinkling timing choices and material-induced uncertainties—rather than merely rendering finished-product aesthetics. Popular-science content involving 3D-printed molds must also clearly state their status as trial-production tools, preventing the public from misinterpreting "printed mold + manual printing" as the complete paper stationery craft.

## 4. Discussion

This section first presents the structural predicaments identified, then summarizes findings and governance implications.

***4.1 Structural predicaments: boundaries and risks of technological intervention***

***4.1.1 Erosion of authenticity: category confusion between algorithmic output and handmade texture.***

The core value of paper stationery lies not in visual perfection of patterns but in the irreproducible contingency of manual practice: the random effects of gold-sprinkling density, the natural bleeding of dyeing, and artisans' immediate adjustments based on daily paper conditions and environmental humidity. Generative AI output is a standardized image fitted by algorithms, lacking the material texture and complete practice process unique to handwork. Without clear labeling, the boundary between AI-generated stationery samples and handmade originals becomes blurred, and the public may confuse digital copies with handmade artifacts, weakening the unique value of handicraft. The essence of this risk is not an image-quality defect but the co-circulation of products generated by different production logics, causing the irreplaceability of handicraft to be dissolved at the cognitive level.

***4.1.2 Copyright boundaries: compliance of training materials and ambiguity of output attribution.***

Generative model training requires massive data, and many existing models draw training materials from public-domain historical stationery catalogues, high-resolution museum images and contemporary inheritors' original works. Historical originals belong to the public domain, but museums' high-resolution digitalization outputs and contemporary inheritors' original stationery samples remain protected by copyright; unauthorized use for model training carries compliance risks. Meanwhile, the copyright attribution of AI-assisted stationery outputs lacks clear legal definition, and the division of rights among prompters, inheritors and AI platforms has no unified standard. The U.S. Copyright Office's 2023 policy states that purely algorithm-generated content is not protected by copyright, but that human creative screening, adjustment and processing of AI materials can form protectable intellectual outputs. The implication for paper stationery is that the creative labor of inheritors in defining style, screening schemes and manual execution should be the core basis for copyright determination, rather than platform one-click generation.

***4.1.3 Weakening of craft subjectivity: erosion of embodied learning by technological dependence.***

The core of living transmission is human craft practice. If apprentices rely excessively on AI-generated schemes, skipping freehand drawing practice, material trial and error and hands-on experience, they may "know

the form but not the principle". Many key judgments in paper stationery—such as the stopping point for gold-sprinkling and the adaptation of binder concentration to paper surface moisture—can only be acquired through repeated practical trial and error and sensory attunement. Algorithms can output idealized finished-product references but cannot provide the learning opportunities afforded by material resistance. When technological tools dissolve the necessity of trial and error, artisans' understanding of materials and procedures tends toward the superficial, creating a risk of hollowing out the craft core. This resonates with international heritage research warning that digital technologies may reshape heritage knowledge production processes (Sánchez-Martín et al., 2025).

***4.1.4 Tension between mold standardization and pattern diversity.***

The "AIGC pattern–3D-printed mold" chain, while improving trial-production efficiency, implicitly compresses pattern diversity. In traditional block-printed stationery, engraving itself is re-creation: knife-force variations, wood-grain direction and accidental carving deviations all leave handmade traces on finished products, and the same stationery sample forms a rich variation spectrum across different artisans and batches. 3D-printed molds derive from a single digital model, with high replication precision and consistency, directly eliminating such handmade variation. If molds are widely used for conventional production, paper stationery patterns will degenerate from a "handmade variation spectrum" to "digital model replication". This risk shares a common origin with the erosion of authenticity but operates through a different pathway: the former occurs at the cognitive-representational level, where algorithmic images are mistaken for handmade originals; the latter occurs at the material-production level, where mold replication weakens handmade variation. The superposition of these two risks will cause paper stationery craft to "retain its form while altering its substance".

***4.1.5 Layered attribution in the mold chain.***

The mold chain extends attribution issues to three dimensions: patterns, digital models and physical molds. The creative contributors may involve prompters, inheritors, AI platforms and printing service providers, and the rights boundaries and usage scopes of each stage require separate agreement. Simply categorizing everything as "AI-assisted design" would both weaken inheritors' control over pattern style and lead to unauthorized mold replication, circulation and diversion to other uses. The mold chain should therefore follow the principle of layered authorization across pattern–model–mold, with inheritors retaining ultimate stylistic control.

***4.1.6 Digital divide: implementation barriers and resource allocation for grassroots workshops.***

High-quality generative models, annotation tools and computing resources require sustained financial and technical investment. Large cultural institutions and universities can build dedicated digital resource libraries; small and medium-sized ICH workshops generally lack funds and digital skills. Without inclusive public tools, the dividends of AI empowerment concentrate in a few resource-rich institutions, and frontline inheritors merely serve as raw-data suppliers rather than becoming participants and beneficiaries of digitalization. UNESCO's Recommendation on the Ethics of AI proposes that AI governance should ensure benefit-sharing and avoid exacerbating existing social inequalities (UNESCO, 2021). Translated to ICH digitalization practice, this means public investment should prioritize developing lightweight, low-threshold tools that inheritors can operate autonomously, rather than merely creating a few high-end demonstration projects.

*Table 4 Structural risks of generative AI intervention and their action pathways*

| Risk | Level of action | Mechanism | Consequence for craft |
|---|---|---|---|
| Erosion of authenticity | Cognitive-representational | Algorithmic images confused with handmade originals | Irreplaceability of handwork dissolved |
| Copyright ambiguity | Legal-institutional | Unauthorized training data; unclear output attribution | Inheritor rights weakened |
| Weakened craft subjectivity | Pedagogical-epistemic | AI schemes replace hands-on trial and error; learners "know the form, not the principle" | Craft core hollowed out |
| Mold standardization | Material-production | Single digital model replicated; handmade variation eliminated | Pattern diversity compressed; craft "retains form but alters substance" |
| Layered attribution in the mold chain | Legal-institutional | Rights of prompter, inheritor, platform and printer unclear | Need for pattern–model–mold layered authorization; benefit-sharing weakened |
| Digital divide | Resource-institutional | High costs of models, annotation tools and computing resources; lack of digital skills in grassroots workshops | AI dividends concentrated in resource-rich institutions; inheritors reduced to data suppliers |

Source: compiled by the authors.

### *4.2 Governance pathway: institutional design centered on inheritor authority*

#### *4.2.1 Tiered labeling: establishing a category order for digital outputs.*

A unified labeling standard should be established, classifying AI-related outputs into four categories with mandatory annotation: (1) referential restoration—virtual completion outputs for restoration research, labeled as hypothetical outcomes, not equivalent to originals; (2) assisted design draft—generated under inheritor leadership and manually realized, labeled as human-machine collaboration; (3) mold-formed artifact—AIGC patterns realized through 3D printing as craft intermediaries, labeled "digital mold–manual application", with mold source and usage boundaries noted; (4) algorithm-generated image—not manually realized, labeled as pure algorithmic output.

To further close the governance loop, future practice may pilot blockchain-based timestamping and hash anchoring for AIGC patterns, digital models and physical molds, so that creation time, modification history and authorization scope can be traced along the "pattern–model–mold–product" chain; this mechanism should complement, not replace, legal attribution and prior informed consent.

Tiered labeling is not merely informing audiences but maintaining epistemological order, institutionally distinguishing handmade originals, digital copies, mold-intermediary products and pure algorithmic outputs, safeguarding inheritor authority and public cognition. Article 50 of the EU AI Act on transparency requirements

for AI-generated content, and its accompanying guidelines distinguishing "fully AI-generated" from "AI-assisted" content, provide institutional reference for this section.

***4.2.2 Authorized training and inheritor-anchored attribution rules.***

Training dataset construction should implement prior informed consent and negotiated permission principles. Public-domain historical materials may be used lawfully; contemporary inheritors' original works and museum high-resolution images require explicit authorization. Output attribution should adhere to the inheritor-led principle: stationery samples for which inheritors define stylistic boundaries, screen and modify schemes and complete manual realization shall have copyright vested in the inheritor or workshop; platforms shall not arbitrarily use heritage-derived materials for other model training or commercial purposes. Layered authorization applies to the mold chain: commercial use of AIGC patterns requires inheritor confirmation; digital models adapted to craft processes belong to the inheritor or workshop that completed substantive modifications; the usage scope of physical molds (trial production, teaching, limited production, batch production) shall be written into authorization agreements, with unauthorized replication, circulation or diversion to other products prohibited. These rules align with copyright law's "human author" requirement while accommodating the collective and intergenerational attributes of ICH knowledge.

***4.2.3 Practice-first pedagogical sequence: hands before algorithms, engraving before printing.***

Apprenticeship and craft teaching should establish a training sequence in which manual practice precedes algorithmic assistance. Learners must first complete basic hands-on operations such as dyeing, sizing and gold-sprinkling, experiencing material properties and practical failures to build foundational sensory judgment before being permitted to use generative tools for conception assistance. For block-printed stationery, learners should first study traditional engraving techniques before contacting 3D-printed molds; only after understanding woodcarving knife techniques, wood properties and the value of handmade variation should they use digital molds for trial production, avoiding equating mold formation with the entirety of printing craft. AI images and 3D-printed molds should serve more as objects for critical discussion than as direct imitation models. Teaching assessment should focus on learners' material judgment and procedural understanding rather than image selection or mold-use efficiency. The core principle: the tacit epistemological core of craft can only be accumulated through manual practice, not acquired by viewing algorithmic output.

***4.2.4 Lightweight inclusive tools: public infrastructure provision responsibility.***

Cultural and tourism authorities and ICH safeguarding institutions, in collaboration with university digital humanities teams, should develop lightweight dedicated toolkits for paper stationery workshops: building foundation models on copyright-clear, curated materials; providing pattern retrieval, restoration sketch reference and document templates; designing simple interfaces that require no complex technical parameters and are accessible on ordinary devices; and providing regular digital skills training to enable inheritors to become system co-builders rather than passive data sources. For the mold chain, toolkits should include shared mold libraries and on-demand small-batch printing public services: public institutions maintain authorized digital model libraries and provide printing services to workshops, reducing the cost burden of independent equipment purchase; shared molds strictly observe authorization agreements, with inheritors retaining pattern style control. The goal of public investment is not to equip every workshop with customized AI systems but to achieve public accessibility of digital infrastructure and safeguard inheritors' control.

***4.3 Discussion: from the paper stationery case to general propositions for living craft skills***

***4.3.1 Epistemological foundations of technological boundaries.***

The paper stationery case distils a transferable core insight: the appropriate positioning of generative AI in living craft skills is at the infrastructure level, not the epistemological level. Algorithms can transform how craft knowledge is archived, retrieved and disseminated but cannot replace tacit craft processes: judgment of

material contingency, absorption of failure experience, and continuous calibration of hand-feel and vision. This boundary will not disappear with technological iteration; even if future models can generate visually highly realistic stationery samples, they still lack the practical knowledge by which artisans decide procedural nodes on the spot in response to specific paper and specific environmental humidity. Positioning AI as an archival and retrieval assistant rather than a learner or creator of craft is precisely to respect this epistemological fact.

***4.3.2 Implications for the digital safeguarding of comparable craft skills.***

The predicaments and governance approaches of the paper stationery case share commonalities with body-practice-dependent crafts such as paper-cutting, lacquerware and woodblock New Year prints, from which three basic principles can be distilled. First, establishing a category order for digital outputs takes priority over technological implementation: before introducing generative tools, a labeling system distinguishing digital products from handmade originals should be established. Second, training-data rights governance takes priority over model construction: inheritors should have control over the conditions under which their knowledge enters training datasets and the directions in which outcomes are used. Third, inclusive tool design takes priority over demonstration project display: avoiding the concentration of digitalization dividends in a few entities. All three principles point to the same conclusion: the legitimacy of technological intervention lies not in technological sophistication but in whether it strengthens the inheritor-led living transmission system. The mold chain in the paper stationery case has direct reference value for crafts that rely on plates and molds for production, such as paper-cutting, woodblock New Year prints and lacquerware decoration. The general implication is that digital molds can be embedded in craft chains but cannot dissolve the function of the "plate" itself in carrying handmade variation. For such crafts, governance should focus not on prohibiting 3D printing but on using labeling, authorization and pedagogical arrangements to clarify that molds are trial-production tools, preserve the independent transmission status of traditional plate-making craft, and prevent a single digital source from compressing the handmade variation spectrum.

***4.3.3 Research limitations.***

This study has two limitations. First, the single-case research design limits statistical generalizability, although the analytical framework can be transferred to comparable crafts and requires testing through additional cases. Second, this paper relies primarily on public materials for theoretical reasoning and lacks long-term field intervention and effect tracking of AI applications within workshops. Future research could conduct digital tool pilots in paper stationery or other craft workshops, using longitudinal observational data to test the practical effectiveness of the governance pathway.

## 5. Conclusion

The transmission predicaments of paper stationery processing technique reflect the general situation of embodied handicraft in contemporary society: fragile organic carriers, highly tacit craft knowledge, dispersed resources, narrow audiences and insufficient financial viability. Generative AI offers practical technical means to alleviate these predicaments—virtual restoration references, semantic pattern retrieval, oral knowledge structuring and lightweight dissemination content—and its empowering value should be acknowledged. Yet technological boundaries are equally clear: algorithms can replicate the appearance and patterns of stationery paper but cannot replicate artisans' situated judgment in response to material contingency, the intuition sedimented from failure experience, and the embodied craft knowledge formed through dialogue between person and material.

The core conclusion of this paper is that the optimal model for generative AI intervention in paper stationery ICH safeguarding is a collaborative division of labor with inheritors as leaders and algorithms as assistants. Algorithms undertake repetitive labor such as archival organization, virtual image restoration, pattern

retrieval and draft generation, liberating inheritors to focus on manual refinement, aesthetic judgment and intergenerational transmission. The technological combination of AIGC patterns and 3D-printed molds expands paper stationery processing means, facilitating small-batch, multi-variety stationery trial production and providing a low-cost craft intermediary for craft restoration and innovation. But molds are always tools, not equivalent to the craft itself; they are suitable for trial production, verification, teaching demonstration and small-batch innovation, while key procedures such as printing pressure application, binder formulation and timing control must retain manual operation, and traditional engraving craft should retain independent transmission status.

The effective operation of this collaborative model requires four institutional supports: tiered labeling to maintain the category order of outputs, incorporating mold-formed products into the labeling system; layered authorization rules to safeguard inheritor rights, distinguishing patterns, digital models and physical molds; practice-first pedagogy to hold the teaching baseline, implementing hands-before-algorithms and engraving-before-printing; and inclusive tools to narrow the digital divide, relying on shared mold libraries to lower equipment thresholds. Technology can become a bridge for the continuation of paper stationery craft, but the far shore of that bridge remains the artisan's hands and the living practice passed down through generations.

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