

Article

From Craft to Code and Back: Biodegradable Polyester, Institutional Co-Design, and Garment Practice in Nishijin Weaving

Kaori Ueda 

Graduate School of Human Development and Environment, Kobe University, Kobe 657-8501, Japan;
ka-ueda@people.kobe-u.ac.jp

Abstract

Nishijin weaving in Kyoto developed as a luxury textile for kimono, yet sustaining the district requires expansion toward contemporary apparel and markets. Within a silk-centred culture and quality regime, polyester has been adopted as a versatile option, and its use has increased, especially for kimono-related products, partly because its filament form can substitute for silk and fit existing processes. From this trajectory, we explore a craft–code–craft pathway by integrating a biodegradable polyester grade into Nishijin’s code-based Jacquard production (CGS). Through practice-based research, we trace how design intent is encoded (Houdini → CGS → Jacquard) and how shop-floor constraints reconfigure design (Jacquard → CGS → Houdini), revealing institutional constraints that shape which materials become usable. We report three case studies: (A) 3D woven structures informed by pleat parameterisation, (B) a zero-waste garment using a 25 cm repeat logic, and (C) a fashion show that makes translation processes legible to the public in an exhibition context. While biodegradable polyester can fit existing infrastructure, apparel-grade warp use remains under development due to warping and warp-joining requirements; yarn specifications and design parameters are being revised. By foregrounding translation across tools, roles, and standards, the study proposes pathways for material transition and circularity within a craft system.

Keywords: Nishijin weaving; biodegradable polyester; zero-waste garment; Jacquard; CGS; procedural design; institutional co-design



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1. Introduction

1.1. Problem Statement: Global Sustainability × Nishijin’s Structural Challenges

Contemporary textile and fashion industries face serious challenges, including escalating environmental burdens and large-scale waste generation. As product lifecycles accelerate, material circulation is not systematically designed, leading to significant environmental impacts. In parallel with these macro-level problems, the traditional Japanese weaving district of Nishijin in Kyoto faces distinct local challenges. Nishijin weaving, known for its highly specialised division of labour, experiences structural difficulties such as a lack of successors, shifts in demand, and delays in adopting digital technology. These conditions raise questions about the sustainability of the traditional manufacturing system itself.

This study aims to bridge two sets of challenges: the ecological pressures confronting the global fashion industry and the technical difficulties encountered in local craft production in Nishijin. The proposed practical approach involves designing and implementing a

“zero-waste one-piece dress” that transcends gender and age constraints, thereby presenting a sustainable model for clothing.

1.2. From a Kimono District to Contemporary Apparel: Polyester Adoption in Nishijin and the Next Steps

Nishijin weaving originally developed as a luxury textile for kimono. However, to secure the district’s long-term sustainability, expansion toward apparel applications connected to contemporary everyday life is essential, thereby renewing both demand and the production base.

Within Nishijin, while maintaining a silk-centred culture and quality regime, polyester has been introduced as a versatile material, and its use has increased steadily, particularly for kimono-related products and accessories. One reason for this adoption is that polyester, as a filament fibre, offers operational compatibility close to filament silk, especially in terms of stable handling as yarn, which has facilitated integration into existing processes.

At the same time, in a production district sustained by a highly specialised division of labour, warp specifications, quality norms, and inter-process connection requirements are institutionally stabilised, making changes to specifications difficult. Therefore, the focus of this study is to examine, through a project, the “practice of transition,” including coordination, translation, and redesign, required for the introduction of a new material to become viable under such constraints.

Building on polyester’s prior diffusion, this study investigates the possibility of integrating biodegradable polyester into Nishijin’s code-based production system (e.g., CGS). Because warp yarns are strongly governed by district-specific requirements, including warping and joining or connecting processes, this is not a simple material substitution. Yet once workable specifications and procedures, including quality assurance, are established within the district, the approach can potentially diffuse across multiple firms. By considering applicability not only in weft but also in warp, this study proposes a pragmatic transition pathway for updating Nishijin’s future material choices toward greater circularity.

In recent years, recycled polyester has become widespread as a “sustainable” option. However, because it presupposes collection, sorting, and reprocessing, circular pathways can become complex in garments that involve blends, finishes, and accessories. Under Nishijin’s production conditions, characterised by a division of labour and small-lot manufacturing, this “collection-dependent” model may be difficult to realise in practice.

1.3. The Meaning of “Institutional” in Nishijin Weaving

In this paper, “institutional” does not primarily refer to governmental regulation or legal frameworks. Rather, it denotes Nishijin weaving’s district-level operational system, in which long-maintained production practices, role divisions, and quality norms are stably intertwined. Concretely, this includes: (1) a specialised division of labour, referring to task-specific expertise and responsibility across processes; (2) shared quality norms, defining criteria for judging what counts as a “good textile” or a “usable yarn”; (3) decision-making by the orimoto/CCM, which coordinates processes and trade-offs across actors; and (4) specification transmission and translation infrastructures based on “code,” such as CGS.

In Nishijin, materials and specifications must satisfy the requirements of multiple interconnected processes, including warping, warp joining or tying, weaving, and finishing, and must also be recognised as weavable under prevailing quality norms. As a result, introducing a new material cannot be treated as a simple substitution. Instead, it constitutes an institutional and operational challenge that requires the simultaneous adjustment of yarn specifications, such as count, twist, and elongation, and process conditions, including

tension, friction, and the feasibility of joining, alongside a reconsideration of evaluative roles and responsibility allocation.

Accordingly, this study examines biodegradable polyester through the lens of how frictions arise between digital design translation processes, specifically Houdini and CGS, and district-specific production requirements, particularly those associated with warping and warp joining. Rather than replacing individual processes, digitalisation functions here as a mediating infrastructure that connects specialised actors and translates design intent into situated judgements of weavability.

In this paper, the central actor responsible for planning and specifying textiles, assuming quality responsibility, coordinating transactions, and commissioning weaving to external parties, is referred to as the CCM (contractor–merchant manufacturer) (In this paper, Morisan Co., Ltd. (Kyoto, Japan) plays that role).

Based on this framing, “institutional co-design” does not refer solely to the collaborative development of a product’s final form. Instead, it denotes a cooperative process centred on the CCM in which weavability itself is collectively redefined through coordinated adjustments to material specifications, digital codes, process requirements, quality norms, and responsibility structures.

1.4. Research Questions and Research Design

The research questions addressed in this study are threefold: (RQ1) within Nishijin’s institutional production system, which process requirements, quality norms, and role divisions function as bottlenecks for enabling a new material, biodegradable polyester, to be accepted as a usable material; (RQ2) how the digital toolchain (Houdini → CGS → Jacquard loom) connects specialised roles across the division of labour and translates design intent into judgements of weavability; and (RQ3) how public practices, specifically clothing in the form of a zero-waste garment and a fashion show, visualise negotiations among material, institution, and code and render them shareable as social questions.

As a research design, this study adopts a research-through-design approach and implements three case studies: (A) 3D woven structures, (B) a zero-waste garment based on a 25 cm repeat logic, and (C) a fashion show. Across these cases, we describe and compare design decisions, process constraints, coordination practices, and insights obtained. Rather than presenting only successful outcomes, material adoption is organised as a transition process that includes unresolved issues and specification changes in warping and warp-joining processes, thereby clarifying how institutional and operational conditions shape material selection and design.

1.5. Related Work and Contributions

This study adopts the perspective that design constitutes a reorganisation of social relations rather than merely the “shape of things” (Manzini 2015), linking zero-waste and biodegradability to institutionally transversal practices. The originality of this research lies in (1) intervening in Nishijin weaving’s historically cultivated code-based textile system through contemporary computational tools and (2) adopting biodegradable polyester, a material that returns to the soil, as the primary material. This fusion of a traditional textile system and a biodegradable material aims not to reproduce nostalgic craft but to pioneer a new material imagination for the future.

This research is situated at the intersection of multiple academic fields. First, it contributes to discussions concerning the relationship between craft and digital technology. The relationship between craft as embodied skill and as abstract code has long been debated, as exemplified by Sennett (2008). More recent studies increasingly examine the two in terms of complicity and translational potential rather than as a dichotomy (Devendorf

et al. 2020). Most such studies, however, focus on individual creative practices or report applications of digital fabrication technology. By contrast, the present study uses computational tools to intervene in the institutional production system of Nishijin weaving itself. In doing so, it foregrounds the possibility of transforming the industrial structure, including the division of labour and professional roles, rather than individual creativity alone.

Second, this research relates to the sustainable design context, particularly the circular economy. Traditionally, sustainability in textile research has focused on utilising recycled materials or reducing waste through zero-waste approaches (Fletcher 2014). While aligned with this trajectory, this study designs the product lifecycle from “beginning” to “end” by using biodegradable polyester, a material that returns to the soil. This concept underpins the effort to digitally connect fabric making and garment production, aiming for a fully independent circular economy while advancing digital circulation. Furthermore, in garment design, this study treats zero-waste as a design language rather than a resource-reduction technique. Rissanen and McQuillan (2016) position garment construction that avoids cut-offs as a creative constraint, placing the negotiation of pattern and volume at the core of design.

Finally, this study is situated within the lineage of critical fashion studies, which treat clothing as a cultural medium (Kawamura 2023). Such approaches question social norms, including gender and consumerism, through clothing. The genderless dress presented in this study is not merely a formal design. It functions as an object that encourages reconsideration of the relationship between humans and materials, including ownership, wearing, and disposal, through the material property of biodegradability.

Based on the above, this study’s main contributions are as follows:

1. **Methodological Contribution:** the presentation of a concrete design workflow for integrating computational tools and biodegradable materials into the traditional Nishijin weaving production system. This workflow serves as a practical model for adapting institutionalised crafts to contemporary technological and ethical demands.
2. **Theoretical Contribution:** this research understands sustainability not merely as burden reduction but as the reformation of relationships. These relationships concern invisible waste and labour arising across materials, production sites, distribution, and consumption. This study positions zero-waste as a design method that reduces such losses. Furthermore, the exhibition functions as a venue for rendering these relationships legible, reconnecting the circuit of production–institution–appreciation.
3. **Practical Contribution:** the feasibility of the proposed method is demonstrated through case studies encompassing 3D weaving design, zero-waste garment production, and exhibition in the form of a fashion show. This practical knowledge offers insights for designers, researchers, and professionals working in traditional industries.

1.6. Material: Biodegradable Polyester

The main material used in this study is a biodegradable polyester that, under specific conditions, is biodegraded by microorganisms into water and carbon dioxide by V&A Japan Corporation. This material contains bio-derived raw materials and is ultimately compostable. In this paper, we do not conduct a quantitative assessment of degradation conditions, rates, or safety. Rather, the focus is on examining the conditions under which a new material becomes usable in relation to the process requirements of a traditional production district.

The reasons for selecting this material are as follows:

1. **Physical Performance:** Biodegradable polyester maintains the durability and shape-retention properties of conventional polyester. Its biodegradability is retained even when blended with natural fibres such as cotton, which distinguishes it from recy-

cled polyester. In contexts where circular design based on collection, sorting, and reprocessing is difficult to operationalise, this material expands design options that explicitly incorporate end-of-life considerations.

2. **Environmental Compatibility:** The property of returning to the soil after use is an essential condition for realising the circular model of “returning to the soil” that this research aims for. This property materially substantiates the concept of design intention intervening even at the product disposal stage. In this study, however, this property is not framed as a justification for environmental release. Instead, it is positioned as a basis for constructing a circular model that includes collection and operational design.
3. **Compatibility with Traditional Looms:** This polyester yarn is intended for use as both warp and weft in existing Nishijin Jacquard looms. This enables new material exploration within the traditional production infrastructure without requiring additional capital investment.

Table 1 compares the polyester yarn used previously with the biodegradable polyester used this time.

Table 1. Comparison of the district-standard warp yarn and the first biodegradable polyester trial warp yarn.

Item	Conventional Warp (District Standard)	First-Trial Warp (Biodegradable Polyester)	Notes
Material	Polyester	Biodegradable polyester	For the biodegradable polyester, prototyping of the yarn profile/geometry is also possible.
Yarn construction	2-ply (plied yarn)	2-ply (plied yarn)	As a 2-ply yarn, the effective linear density is doubled (e.g., 50D single → approx. 100D as plied).
Linear density/yarn count	50 denier (D)	36 dtex	Denier and dtex are different units (dtex = denier ÷ 9).
Filament count	36 filaments (36F)	36 filaments (36F)	Bundle of 36 filaments.
Twist (direction & amount)	S-twist: 900; Z-twist: 500	S-twist: 500; Z-twist: 300	Values are reported as provided (units follow the mill’s convention).
Finish/spin finish	Unknown	Heat-set: 70 °C for 45 min	(If there is also a spin finish/oil, you can add it here later.)
Yarn dyeing	Yarn-dyed within the district (pre-dyed)	Yarn-dyed via V&A Japan (pre-dyed)	V&A Japan’s products are often developed for sports applications, where piece dyeing is more common.
Warping	Feasible within the existing workflow	Feasible within the existing workflow	
Warp joining (splicing/tying)	Feasible within the existing workflow	Not feasible within the existing workflow	The joining issue may be addressed by matching the yarn profile/geometry.

1.7. Method: A Toolchain That Iterates Between Digital and Analogue Processes

This research employed a method that alternates between digital tools and traditional looms across design and production processes. In this paper, the term “toolchain” does not refer to a linear, software-only pipeline. Rather, it denotes a linked sequence of translation and adjustment that oscillates between (i) a process of reducing design intent into weavable specifications (Houdini → CGS → Jacquard loom) and (ii) a feedback loop in which shop-floor requirements, such as yarn behaviour, tension, and joining, reconfigure the design (Jacquard loom → CGS → Houdini).

- **CGS (Computer Graphics System):** This study used a weaving design application tailored for Nishijin weaving patterns, developed by the Kyoto Municipal Institute of Industrial Technology and Culture (currently CGSII) ([Kyoto Modern Dyeing and Weaving Technology Development History Compilation Committee 1990](#)). CGS converts design drafts into punched card data, the digital equivalent of the punched cards read by the Jacquard loom ([Ueda and Voorwinden 2022](#)). In this research, CGS was used to convert 3D patterns generated by Houdini into loom data (Figure 1).
- **Houdini (version 19.5):** This is 3D procedural modelling software developed by SideFX. In this research, Houdini was used to simulate the 3D structure of the textile, including 3D weaving and drape aligned with body movement, and to generate the final dress pattern. The procedural modelling approach enabled rapid design iteration through parameter changes.
- **Japanese-Style Jacquard Loom:** For production, this study used an electronic Jacquard loom with 1296 hooks owned by Morisan Co., Ltd., a coordinating firm (CCM) in the Nishijin weaving district. Although digitised, loom operation and yarn preparation, such as warping and heddle threading, were carried out manually by skilled artisans. Japanese-style Jacquard looms are used throughout Nishijin. They have undergone unique modifications over a long history and can weave intricate patterns on small machines, but they also face challenges, including delays in digitalisation ([Hashino and Otsuka 2013](#); [Sato et al. 2020](#)). In this study, the orimoto (CCM) played a key role as the actor responsible for specification adjustment and decision-making across multiple stages of the loom-related workflow, including warping, warp joining, weaving, and finishing (In this paper, Morisan Co., Ltd. plays that role).

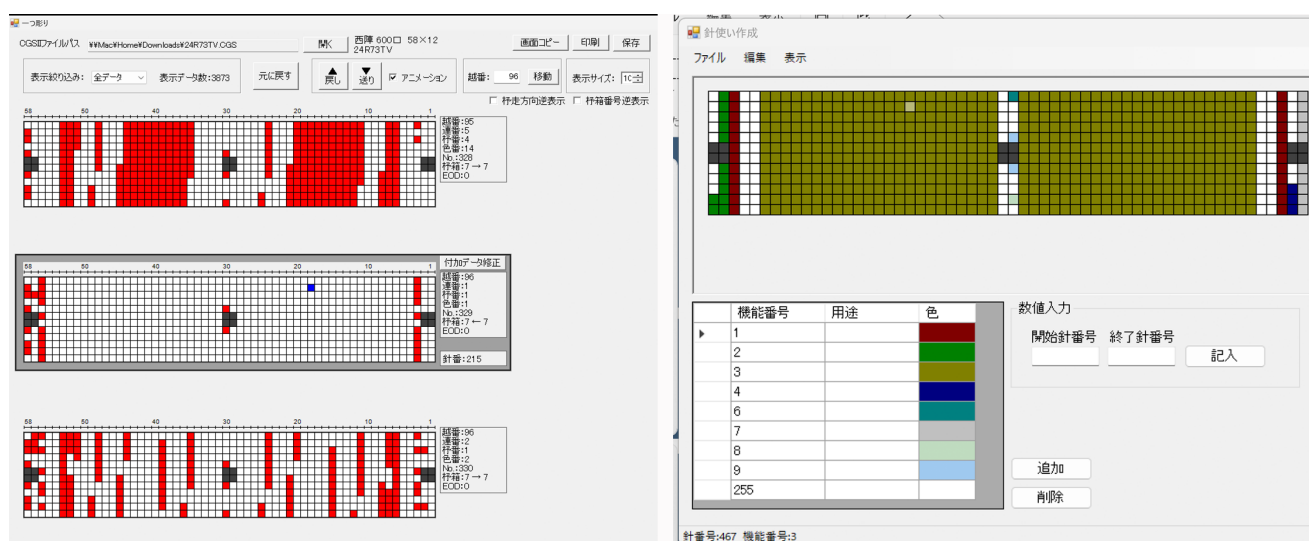


Figure 1. Design data via CGSII. Data are standardised to allow for designing according to the loom’s specifications. In the right diagram, colour codes 1 and 2 indicate mechanisms specific to Japanese-style Jacquard looms, while colour code 3 represents the Jacquard needles (600 needles in this case).

Despite the initial assumption of compatibility with traditional looms, the biodegradable polyester used in this research revealed a technical connection issue during actual weaving. Specifically, the yarn, originally intended for sports fabrics, differed from conventional Nishijin warps in twist direction and rotation count and exhibited high elasticity. These properties caused difficulties in connecting warp threads. As a result, warp yarn specifications were modified to more closely match conventional ones in terms of physical properties. This experience indicates that introducing new materials is not merely a technical substitution but a complex challenge involving institutional standards and the embodied skills of artisans.

Furthermore, the CGS used in this research is a Japanese weaving design application that digitally formalises the traditional punched card system of Nishijin weaving. The punched card functioned as the code of weaving, controlling warp lift by reading holes punched into paper cards. CGS inherits this binary control logic of punched cards and accurately translates traditional weave structures from digital designs.

This CGS system has long functioned as a shared language (common code) connecting design to physical production within Nishijin's highly specialised division of labour (e.g., designers, pattern makers, weavers). By linking CGS with Houdini, this study constructed a "code translation process" that enables new material expression (3D weaving) while preserving the traditional production infrastructure. Describing this reciprocal translation itself concretises the special issue theme—"from craft to code, and back to craft"—as a making process.

1.8. Evaluation and Recording Procedure

The following procedures were adopted to verify efficiency and sustainability:

- **Zero-Waste Pattern Verification:** To eliminate waste material (cutting scraps) in garment production, Houdini was used to optimise the width of the fabric to be woven (in this case, four repeats of 25 cm width) as well as the final dress pattern. The generated pattern can constitute a single garment without wasting any fabric. This verification was performed by first calculating the area of the pattern pieces digitally, confirming they precisely match the total area of the woven fabric, and then empirically confirming that no physical cutting scraps were produced during the final sewing stage.

In this paper, this verification is positioned not as an engineering evaluation aimed at strict experimental reproducibility, but within a research-through-design framework that documents and examines the chain of design–translation–weaving within Nishijin's highly specialised production process. Accordingly, zero-waste was ensured through a two-stage confirmation: (i) digital verification of area equivalence and (ii) confirmation of the absence of cutting offcuts during the sewing stage.

2. Case Study A: 3D Weaving Design and Implementation

As the first stage of the research, this section details the process of designing a 3D textile using digital tools and physically implementing it through Nishijin weaving techniques. The aim was to establish a design method that digitally controls the material structure of the fabric itself, including texture and unevenness, in contrast to Nishijin weaving's conventional emphasis on two-dimensional pattern expression.

This section explains the design of a 3D textile by incorporating pleats into the fabric structure and integrating them with Nishijin weaving technology. Here, three-dimensionality is treated not as an extension of surface patterning, but as a material structure emerging from combinations of weave structures, density, and layered constructions, resulting in relief, variations in softness and hardness, and degrees of lift.

The most distinctive feature of this production process is the collaboration between general-purpose 3D design software (Houdini) and the dedicated software (CGS) used in Nishijin weaving facilities. Production proceeded through the following four steps:

- Step 1: Conceptualising the Pleat Design: First, the pleat design forming the basis of the final design was conceptualised. After observing existing pleating machines, three types were selected: (1) horizontal pleats, (2) vertical pleats, and (3) combined vertical and horizontal pleats (Figure 2). Although simple, this classification enabled control over the spacing and width of the pleats' mountain and valley folds and supported parameter-based fabric design.

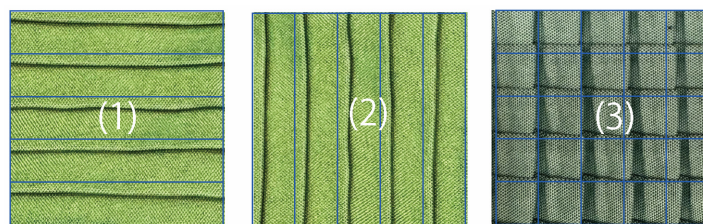


Figure 2. Comparison of pleat shapes: (1) horizontal pleats, (2) vertical pleats, and (3) vertical and horizontal pleats. This project, the pleats were set with 1.5 cm face folds and 0.5 cm under folds.

At this stage, the process remained a shape design not yet linked to the final weaving method. The classification and design vocabulary for pleats followed Jackson (2015), and the description of fabric shape change using belt-like parameters followed Haynes and Steimle (2024).

- Step 2: Translating the Design to the Actual “Weaving Method”: Next, the shape design created in Step 1 was mapped onto the weaving method (weave structure), which serves as the concrete blueprint for the textile. This step involved assigning how and where each part of the design would be woven. For instance, double weave was primarily adopted to achieve lightness, softness, and reversibility (Figure 3).

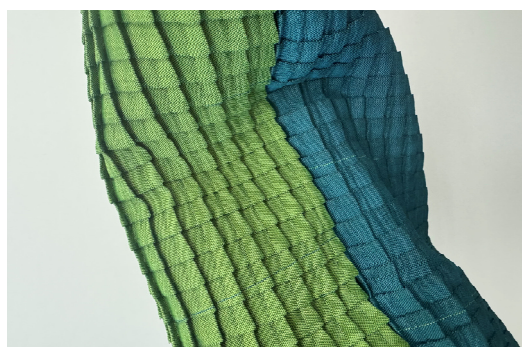


Figure 3. Example use of double weave: Double weave was adopted to enable reversibility. Because it can also form tube-like structures, it was applied to three-dimensional parts such as sleeves. In this sample, green weft yarn was used for the upper layer and blue weft yarn for the lower layer.

Double weave is a technique in which two layers of cloth are woven simultaneously and can be locally connected or separated, making it suitable for designing pouch-like (tube) structures. In this study, the placement of separation and binding points between layers was examined to secure tactility and mobility.

- Step 3: “Translation” to Dedicated Loom Data: The weave structure data created in Step 2 was imported into the dedicated software (CGS) used at the Nishijin weaving facility and compiled into punched card control code interpretable by the Jacquard loom. Final adjustments for yarn type, density, and colour were also made within this

software. The translation here is not a mere file conversion. Rather, it is the process of reducing design intent into weavable data that conforms to loom specifications, including harness count, repeat, and arrangement, as well as process requirements governing yarn choice, density, and colouring.

This translation differs depending on the Jacquard format. However, digitalisation broadens textile possibilities and enhances design freedom (Holyoke 2013). Furthermore, treating weave design as a parametric notation that can be iterated aligns with discussions surrounding AdaCAD (Devendorf et al. 2023). Building on these debates, this study demonstrates through the production process that encoding specification differences in Japanese-style Jacquard looms within CGS is effective for connecting a highly specialised division of labour (Ueda and Voorwinden 2022).

- **Step 4: Weaving the Fabric and Setting the Pleats:** Finally, the completed data were sent to the loom, and the fabric was woven using biodegradable polyester yarn. However, because the use of biodegradable polyester as apparel warp has not yet been established under locality-specific requirements for warping and warp-tying processes, Case Study A used biodegradable polyester as the weft, while employing a yarn specification that can be stably operated on-site in Nishijin for the warp.

The evaluation in this section is not intended to identify material properties or conduct quantitative durability tests. Rather, it is positioned as an implementation-oriented verification of the consistency of design–translation–realisation, namely, whether the intended geometry was achieved as planned.

Regarding the application of biodegradable polyester in the warp, trials are ongoing while revising yarn specifications and process conditions in response to the present weaving results.

The finished product was evaluated to confirm that it maintained the three-dimensional form precisely as designed digitally. While a systematic framework relating material, process, and shape has been discussed in research on self-folding by Narumi et al. (2023), this study does not focus on engineering performance evaluation. Instead, it documents a design–translation–implementation process through which weavability is sustained within Nishijin’s highly specialised production system.

The key insight from Case Study A is that the bottleneck in introducing a new material lies less in weaving itself than in the operational requirements of the warp, including warping and warp tying. This indicates that a material does not become usable merely because it performs well in isolation; rather, it must be translated into a specification that aligns with locality-specific process conditions and quality judgements. In addition, the process of making the design viable as loom data through the CGS format can be described as a staged translation from shape to structure to code.

3. Case Study B: 25 cm Repeat × Genderless Dress Design

This section describes the process of designing and implementing a zero-waste one-piece dress, wearable regardless of gender or age, using the 3D woven textile produced in Case Study A. The objective was to integrate the entire process, from material development in Case Study A to garment production and use, within a consistent ethical and ecological framework (Fletcher 2014; Manzini 2015).

This case study also constitutes an attempt to translate a repetition constraint derived from locality-specific loom specifications, namely a 25 cm repeat, into both the visual composition of the garment and the logic of pattern design.

3.1. Design Challenge: Balancing Technical Constraints and Concepts

Beyond Japanese-style Jacquard looms, digitalisation is advancing in Jacquard weaving globally, enabling diverse design possibilities. However, effective design requires working with, rather than against, the specific characteristics of each loom (Holyoke 2013). The primary technical constraint in this case study was the 25 cm repeat pattern dictated by the loom specifications. This repetition needed to be aesthetically integrated into the overall garment form, rather than appearing monotonous (Jackson 2015). At the same time, the design was required to realise two concepts within a single piece: zero-waste, defined as the absence of cutting scraps, and genderless design, accommodating diverse bodies (Rissanen and McQuillan 2016).

Accordingly, the design focus lay in simultaneously achieving: (i) placement in which repeat boundaries do not appear as visual noise, such as by converting them into deliberate accents at hems and sleeves; (ii) a cutting and layout plan in which fabric width functions as pattern width; and (iii) a silhouette and ease allowance that accommodates bodily variation.

The notation of weaving in this design aligns with the HCI framework AdaCAD for parametrically representing complex weave structures (Devendorf et al. 2023). However, what this study primarily examines is not the proposal of a new notation system as such, but the practical work of translation between region-specific code (CGS) and garment design, made concrete through a case.

3.2. Digital Workflow from Pattern Generation to Virtual Fitting

To address this challenge, this research constructed the following digital workflow using Houdini:

- Zero-Waste Pattern Generation and Virtual Fitting
 - (1) Pattern generation: Zero-waste 2D pattern pieces were generated by optimising the width of the fabric to be woven, in this case, four repeats of 25 cm, together with the final dress pattern. In this optimisation, layout rules were adjusted to satisfy simultaneously: (i) that the pattern outline fits entirely within the fabric width, equivalent to 1 m; (ii) that pattern pieces can be placed without gaps; and (iii) that the 25 cm repeat boundaries appear at visually intended positions, such as hems and sleeves.
 - (2) Virtual assembly and fitting: The generated 2D pattern pieces were sewn together, in virtual space and fitted onto a 3D digital avatar for virtual fitting. This simulation utilised Houdini's physics engine, the Vellum Solver. Physical parameters, including the density and stiffness of the biodegradable polyester yarn, were set to reproduce the fabric's drape and its compliance with body movement.

However, the parameter settings in this study were not intended as a reproduction experiment in which values derived from material testing are precisely applied. Rather, they were operated as a design exploration to support prototyping and fitting decisions through iterative adjustment of behavioural parameters such as density, stiffness, and damping (see Section 1.8).

This virtual fitting played two critical roles:

Avatar evaluation: To represent diverse body types and genders, selected shape and measurement features were parameterised and bespoke avatars were generated by linking Houdini with CLO3D (Figure 4). At minimum, representative measurements—height, bust, waist, and hip circumferences, shoulder width, and torso depth—were treated as variable parameters. The evaluation focused on silhouette stability under a single pattern, including the absence of excessive tension, pulling, or local collisions. This framework enables assessment of a universal fit and silhouette not constrained by gendered attributes.

However, constructing avatars suitable for try-on requires substantial iteration and cannot be achieved in a single step (Loper et al. 2015; Gill et al. 2023; Zhang et al. 2024).

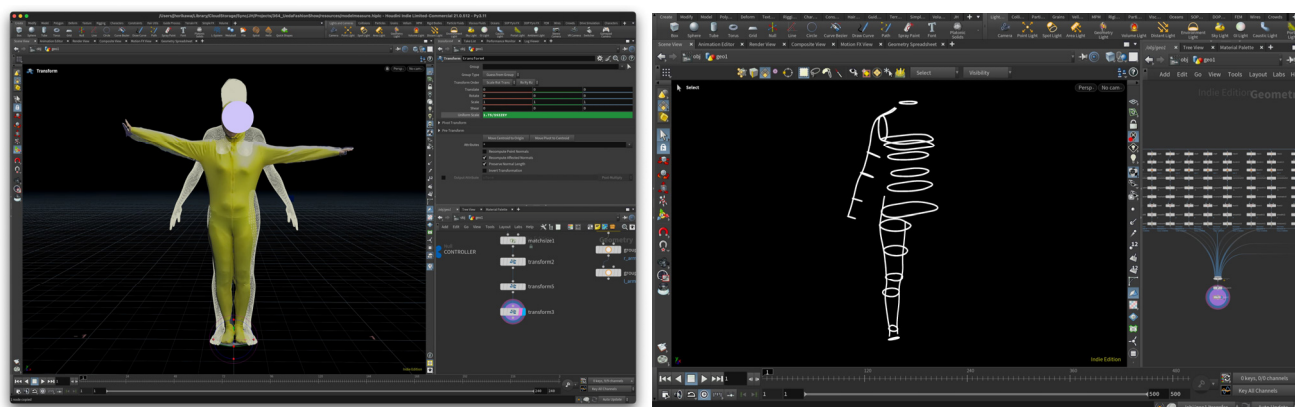


Figure 4. From 3D body scan data to parametric modelling in Houdini. (Left) Size comparison between existing 3D model and project model. (Right) We are currently exploring dimensional measurement methods due to the difficulty of performing 3D scanning easily.

Reduction of Physical Prototyping: This approach omitted the process of physically cutting and sewing fabric to create trial samples, thereby reducing time and material use. It represents an extension of the trial-weave-less design philosophy discussed in Section 1.8 (Vahid et al. 2021; Pietroni et al. 2022). The contribution of this study lies in presenting a concrete procedure for realising a zero-waste garment under Nishijin’s width constraint (25 cm × 4 repeat) and CGS-derived design specifications, while remaining consistent with these prior frameworks.

3.3. Final Verification and Implementation of Zero-Waste

The fabric, modulated into four 25 cm-wide sections from a one-metre width, was further cut to one-metre lengths for pleating. These sections were then used to devise waste-free designs for both children’s and adult garments, sewn using straight-cut patterns. To utilise the double-weave structure, some sections incorporated cotton batting for volume, creating designs that leveraged the pleats’ elasticity. Furthermore, the polyester was cut using ultrasonic cutting, preventing fraying and eliminating waste. Both models were finished solely through cutting, straight-line sewing, and hand-stitching. Using the same modules and applying the same zero-waste principles allows for diverse designs and seasonal variations. Here, an example of a women’s design is presented (Figure 5).

This dress has a straight silhouette that does not cling closely to the body, while the texture of the 3D weaving generates rich surface expression and drape. The shifting interplay between glossy and matte sections as the wearer moves characterises clothing not as a static object but as a dynamic performance. The 25 cm repeat pattern functions as an intentional visual accent at the hem and sleeves, transforming a technical constraint into design originality.

Moreover, the realisation of zero waste is not limited to the absence of cutting scraps. Rather, it resides in re-linking production-side constraints of width and process with garment-side pattern logic as a single design problem. The following section examines how this translation process can be presented as a public practice through a fashion show, and how negotiations around materials, institutions, and code can be made socially legible.

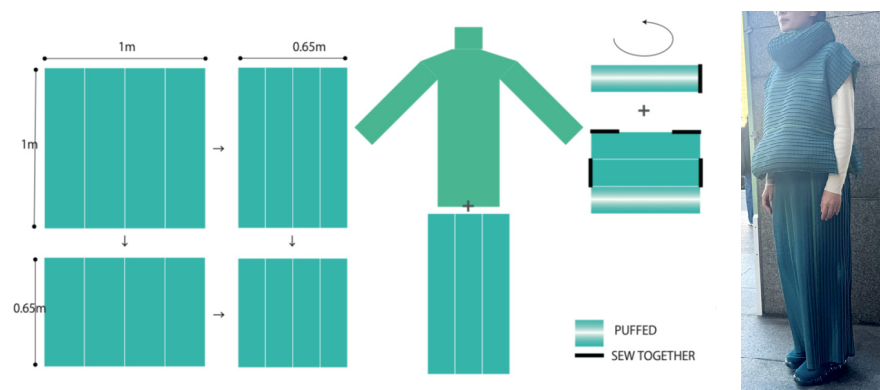


Figure 5. (Left) Dimensions for pleating a 1 m square fabric (double-weave with 25 cm closed-end pockets). Centre: Zero-waste design using the fabric on the left. The gradient section utilises the double-weave structure, with padding inserted inside. The plus sign (+) denotes sections that are sewn together to form the garment structure. (Right) Photograph of the garment being worn.

4. Case Study C: The Fashion Show and Subsequent Exhibition as a Communication Medium

Fashion is often noted for beauty and trends, yet it also conveys messages concerning social issues such as gender, race, and the environment (Entwistle 2015). The outcome of this research was positioned not as a self-contained garment but as a medium situated within a social context to stimulate discussion (Koskinen et al. 2011; Barry 2017). Rather than treating the fashion show and exhibition as a mere presentation of finished objects, this section describes how they were designed, procedurally, as a research event that makes visible processes of making, translation, and institutional adjustment, and that uses audience responses to examine research concerns relating to material, body, and institution.

As a concrete practice, a fashion show, “Oh!NeoNeo,” held on 15 November 2025 at the Nishijin-ori Kaikan (Kyoto, Japan), was planned and executed in the Nishijin weaving district. The show was co-organised by a local textile industry association and Kobe University and Kyoto Saga University of Arts, with cooperation from a materials supplier V&A Japan Co., Ltd. (Osaka, Japan), and was staged at a local textile exhibition hall (Nishijin-ori Kaikan) (Figure 6). Within this research, the show was positioned as a node that (i) translates hypotheses emerging from the research process into questions examinable in a public setting and (ii) feeds the resulting responses back into subsequent design iterations and specification revisions.

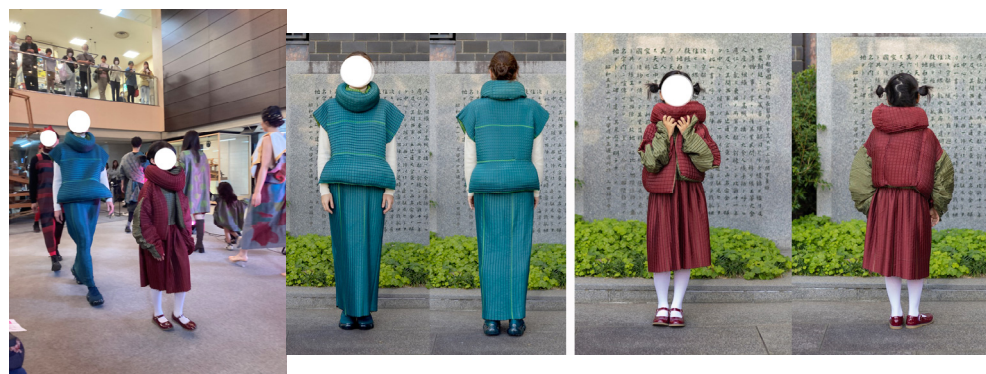


Figure 6. (Left) Photographs from the Oh!NeoNeo fashion show held at Nishijin Textile Center (Nishijin-ori Kaikan) (Kyoto, Japan) on 15 November 2025. (Right) Author's works, which are designed for this project.

4.1. Exhibition Objective: Visualising Process and Narrative

The primary objective of this fashion show was not merely to display the finished dress, but to make visible the otherwise invisible processes and narratives underpinning it, including the dialogue between tradition and innovation, the reciprocal relationship between digital and material practices, and what it means to be clothed (Entwistle 2015). The show adopted the concept of a genderless, ageless one-piece, featuring models of different ages and genders, thereby presenting clothing as a universal entity not constrained by specific physical attributes. By presenting garments interacting with diverse bodies and behaving dynamically in space, rather than as static exhibits, the fashion show provided an effective means of articulating the research concept. The research process itself was guided by the notion of a genderless, ageless one-piece throughout production (Barry 2017). Crucially, the contribution does not lie in an impressionistic claim that the show added depth to the research; rather, by explicitly setting the presentation format as a premise, design decisions and evaluation perspectives, such as movement, bodily variation, and institutional constraints, were aligned from an early stage.

4.2. Exhibition Design Intended to Encourage Diverse Interpretation

To achieve this objective, the exhibition aimed to establish a shared ground through which individuals with different backgrounds, including researchers, designers, artisans, and general audiences, could understand the research significance from their respective perspectives and engage in dialogue (Björgvinsson et al. 2012). The contribution of this study lies in designing this common ground not as the garment alone, but as a set of relations among materials, processes, tools, and roles. To this end, the following three elements were designed to function as media enabling diverse interpretation:

- **Installation:** The stage for the show was the Nishijin Weaving Expo, a general exhibition venue for Nishijin weaving. Accordingly, the show presented works by participating students together with the researcher's work in a 15 min fashion show under the concept of the genderless, ageless one-piece. At the same time, the research outcome was communicated visually as a composite configuration that included not only the dress but also raw biodegradable polyester yarn, a screen projecting simulation footage created in Houdini, and selected components of the Nishijin loom, such as heddles and shuttles. Audience members interpreted these elements individually while collectively engaging with the research narrative of "Craft to Code, and Code back to Craft." This configuration indicates that the digital does not replace craft; rather, it functions as a common language, or code, for transferring intent across processes.

Drawing on Latour's concept (Latour 2005), this view understands dress not as a standalone artefact but as an assemblage comprising yarn, images, components, and processes. To avoid conflating the exhibition design implemented in this study with existing theory, Latour's framework is presented separately as an explanatory alignment rather than as a methodological foundation.

- **Social Relevance:** Biodegradable polyester is a necessary material for the future, often described as the fibre that becomes the soil of the future. However, integration remains difficult within existing frameworks due to differences in yarn specifications, and it has not yet been adopted in Nishijin. What this study demonstrates is not a claim of full implementation, but the possibility of making visible and shareable with audiences the friction points that prevent adoption, such as yarn specifications, warping, and warp-knotting processes. These points can be connected to redesign on the production side through specification revision. Importantly, collaboration here is not framed as a celebratory account of generic industry–university partnership; the em-

phasis lies in treating the connection points of the division of labour, including specification agreement, quality norms, and responsibility allocation, as design objects (Etzkowitz and Leydesdorff 2000; Manzini 2015).

- Significance of Digitalisation: The fashion show involved approximately 30 participants and the production of around 30 different outfits in a short period. Digitised data were essential. Student designs were converted into textile designs, woven, and made into garments. This process embodied “Craft to Code, and Code back to Craft.” The ability to weave different design fabrics simultaneously was enabled by a system that codified and materialised designers’ ideas (Holyoke 2013; Devendorf et al. 2023; Zhang et al. 2024). The claim is not that digitisation is universally effective, but that under short-turnaround conditions, it functioned as a mediator that reduced translation costs across processes.

Through this exhibition design, the fashion show functioned as a shared ground for people with different knowledge backgrounds and values to reflect on and engage in dialogue around the research themes of designed temporality and the future of institutional craft (Bjögvinsson et al. 2012). By presenting not only the finished product but also the complex processes and constraints behind it, the research moved beyond a mere design proposal. It functioned as a form of critical practice that questions the values on which contemporary textile culture should be based.

4.3. Designed Public Sphere: The Show as a Pre-Planned Research Publication

In this project, the fashion show was not a presentation of a finished product but a pre-planned research event. Its aim was to translate hypotheses developed during the making process into questions examinable through dialogue with local residents and audiences. In this sense, the show functioned as research-through-design, creating encounters in which audience responses were gathered and fed back into the research (Koskinen et al. 2011; Barry 2017).

In this study, the fashion show was treated as a site for generating research data. We collected: (i) short free-text audience comments, such as comment cards; (ii) notes from remarks made during a talk-back session; (iii) observational records from the day in the form of researcher memos; and (iv) process logs of design and production, including records of specification changes, weave design, and pattern verification. These materials were organised from three perspectives—material, bodily experience, and institution—and iteratively coded to extract key themes.

The analysis does not claim statistical representativeness; rather, it aims to describe, in a form connectable to redesign, the frictions and learning made visible in a public setting. Documentation focused on short audience comments and talk-back sessions, which were initially analysed across three perspectives: material (how the fabric behaves), embodiment (how it interacts with different bodies), and institution (how roles and standards shape what becomes possible) (Barry 2017). The “institution” lens operationalises the definition of institutional introduced in Section 1: division of labour, quality norms, role allocation, and specification agreement, used here as a framework for observation and description.

In this way, the act of showing also became a form of publishing: a designed public sphere in which presentation itself produced analysable evidence for reflection. Finally, in this paper, institutional co-design does not refer to one-off collaborative making; rather, it denotes an approach that treats the coordination of agreements across divided processes, including specifications, quality, and responsibility allocation, as design objects. Its conceptual definition and scope of application in this study are clarified again in Section 5.2.

5. Discussion

This research aimed to present a realistic model for sustainable textile production by introducing computational design and biodegradable materials into the traditional institutional craft of Nishijin weaving. The workflow demonstrated across the three case studies is not limited to technical experimentation; rather, it holds significance as a concrete and practical response to contemporary challenges facing traditional industries. This section discusses three core arguments derived from this work.

5.1. Constructing a Realistic Circular System: The Practical Value of Biodegradable Materials

“Sustainability,” as presented in this research, is not a conceptual ideal. It is a realistic approach achieved by selecting biodegradable polyester and actively designing the entire product lifecycle, from inception to disposal (Fletcher 2014; Manzini 2015). Here, “realistic” does not refer to an “ideal optimum” that requires new large-scale facilities or imposes excessive sorting burdens on consumers; rather, it refers to design options that can operate within Nishijin’s existing infrastructure (loom specifications, a division of labour, and quality assurance and coordination centred on the coordinating firm, i.e., the CCM).

In the contemporary fashion industry, “sustainability” often faces implementation challenges, such as the complexity of recycling systems and excessive burdens placed on consumers. By contrast, the “return to the soil” model adopted in this research can significantly simplify the circular process. That said, this study does not claim to have fully demonstrated end-of-life processing. Quantitative verification of degradation conditions, relevant standards, actual disposal routes (e.g., industrial composting or municipal collection), and degradation rates is beyond the scope of this paper and is identified as a limitation in Section 5.3.

The contribution of this study lies, instead, in showing, through a process of making, translation, and implementation, how far material selection that anticipates an endpoint can be made operational under the institutional conditions of a traditional production district. This public presentation (fashion show/exhibition) is also connected to discussions that frame fashion as a catalyst for social circulation (Entwistle and Rocamora 2006).

At the same time, the study shows that biodegradable polyester, particularly in relation to warp specifications, cannot be treated as a simple material substitution. A new material becomes operational as a usable material only when it is connected to institutionalised requirements such as warping, warp tying/joining, tension management, and quality norms. Accordingly, introducing biodegradable materials is not merely the substitution of fibres; it entails practical adjustment, an enacted transition that includes process requirements and negotiated specifications. If these conditions can be established, it may become possible to update material choices towards circularity from within the production district, without fundamentally altering existing infrastructure.

5.2. Institutional Co-Design: The Catalyst for Incremental Innovation

The practice demonstrated in this research represents a model of incremental innovation that updates the existing framework from within while respecting it. This approach differs from radical transformation (disruption) that overturns traditional production systems (Lawrence and Suddaby 2006; Hashino and Otsuka 2013). As outlined in Section 1.3, the institutional conditions discussed here refer to an operational system in which division of labour, quality norms, material conventions, specification agreements, and allocations of responsibility combine to determine “what can be woven” and “what is permissible”.

On this basis, the “institutional co-design” proposed in this study does not refer to jointly designing a final product form. Rather, it denotes a collaborative effort to provisionally redesign the specifications, procedures, and decision frameworks (i.e., weavability) re-

quired to make a new material viable as a usable material. Specifically, the co-design claim advanced in this paper is limited to three aspects: (i) the provisional setting of yarn specifications and operating conditions, particularly those required for warp operation; (ii) the establishment of procedures for data translation and handover via CGS as a shared code across processes; and (iii) the assembly of an agreed account and evaluation viewpoints, including public practice, through which new values such as circularity and efficiency can be connected to existing quality frameworks without direct conflict.

As evidenced in Case Study A, the bottleneck in introducing new materials does not lie in design itself, but tends to arise at institutionalised connection points such as warping and warp joining. At these points, tacit specifications, embodied craft skills, and quality norms determine feasibility. Consequently, material introduction becomes less a problem of material substitution and more one of operational design, encompassing process requirements and accountability for judgement. In this sense, the iterative exchange between Houdini and CGS functioned not merely as a production tool but as a translation device that fed on-site constraints back into the design space and rendered specification adjustment negotiable.

Crucial to enabling this collaboration is the position of the CCM (the coordinating firm). As a hub for quality assurance and inter-process coordination, the CCM structures the scope of permissible trials within the production network. Accordingly, this study shows that the CCM can function as an anchor that maintains existing quality norms while legitimising limited new-material trials and facilitating agreement among stakeholders. The key point is that ethical value (circularity) and efficiency value (reducing trial weaving) are not embedded as abstract slogans, but are translated into practical arrangements—such as handling requirements, tolerances, and allowable ranges of manual intervention—through which they become embedded within institutional conditions.

Furthermore, the public practice described in Case Study C was positioned as a node that renders visible, as shareable points of discussion, frictions that typically remain invisible within the production district, including specification agreements, process connection points, and role allocations. It also connects these frictions to subsequent specification revision and redesign. However, this paper does not claim a direct causal relationship in which public presentation immediately results in permanent adoption or diffusion across the district as a whole. Rather, it is presented as a plausible mechanism inferred from audience and stakeholder responses and from the continued process of specification revision, while the tracing of diffusion is identified as a task for future research in Section 5.3.

5.3. Limitations and Remaining Challenges

While this research presented a concrete model for integrating computational tools and biodegradable materials into the traditional production system of Nishijin weaving, some limitations and remaining challenges became apparent during implementation.

1. **Provisional Handling of Technical Incompatibility:** Although biodegradable polyester was initially assumed to be compatible with existing looms, a connection issue emerged because the yarn, originally intended for sports fabrics, had specifications (twist direction and rotation count) that differed from those of conventional Nishijin warps. This issue was provisionally addressed by modifying the warp yarn to specifications closer to conventional physical properties. This outcome indicates that introducing new materials is not merely a matter of technical substitution but involves updating institutional structures, including established material customs and the embodied skills of artisans. However, the present solution remains ad hoc; long-term acceptance of new materials will require sustained alignment between international yarn standardisation and Nishijin's technical practices.

2. **Diffusion of Digital Tools and the Succession of Craft Skills:** The introduction of computational tools such as Houdini and CGS increased production efficiency and enabled 3D structural expression. Nevertheless, a future challenge remains in ensuring that the acquisition and operation of these new digital codes do not become an additional technical or economic burden for artisans and successors. Addressing this challenge will require improvements to tool interfaces as well as the establishment of dedicated educational systems.
3. **Insufficient Verification at the End-of-Life Stage:** This study positioned the “return to the soil” property of biodegradable polyester as a significant ethical value. However, empirical data on the product’s actual lifespan, decomposition rate, and safety within composting processes fall outside the scope of this research. To fully verify the efficacy of this circular model as a “reliable exit strategy,” long-term experiments conducted in actual composting environments are indispensable.

6. Conclusions

This study presented a concrete practical model addressing how the traditional craft system of Kyoto’s Nishijin weaving can respond to contemporary ecological and technological demands. The workflow integrating computational tools (Houdini, CGS) and biodegradable polyester demonstrated a realistic path for achieving sustainability and new forms of aesthetic expression within the institutional framework of traditional craft. The series of case studies—from 3D weaving design to zero-waste garment production and exhibition practice—showed how abstract concepts can be materialised into concrete substance, form, and social context.

The contribution of this paper is not to claim a final, fully implemented outcome (i.e., complete adoption), but to make visible, through a digital–analogue implementation process, where and under which institutional conditions frictions arise when introducing a new material, and what kinds of adjustment and translation are required.

The circular model proposed here, which positions biodegradability as a “reliable exit strategy,” and the institutional co-design approach, which translates different forms of expertise, can offer valuable insights not only for Nishijin weaving but also for other traditional industries facing similar challenges. However, given that on-site verification remains insufficient at present with respect to degradation rates, applicable standards, and actual disposal routes, the phrase “reliable exit strategy” is used here in a qualified sense: as a framework that makes end-of-life explicit as a design variable and renders the conditions for circularity open to discussion. In other words, this study does not present composting as a “guaranteed ending”; rather, it is practice-based research that asks how far material selection and workflow design, including end-of-life considerations, can be made operational under the institutional conditions of a traditional production district.

This research aimed to redefine the theme of “Craft to Code, and Code back to Craft,” not merely as a technological back-and-forth but as a social and material practice for weaving an ethical and ecological textile culture for the future. The redefinition proposed here does not suggest that digitisation replaces craft; instead, by treating codes such as CGS as a shared language across processes, it becomes possible—in a limited and specific sense—to approach institutional frictions as design objects, including handover points created by the division of labour (specification agreements, quality norms, and warping/joining operations).

The findings of this research offer transferable insights into how highly specialised traditional crafts and regional industries can respond to contemporary ethical and technological demands beyond Nishijin weaving. However, the claim of broader relevance is not presented as a generalisation of results; rather, it is advanced as the “transferability” of

three lines of argument: inter-process translation, institutional adjustment, and material choice that explicitly incorporates end-of-life design.

- **Universalisation of the Circular Model:** As a future outlook, the circular model using biodegradable materials as a “reliable exit strategy” proposed in this research needs to be applied to a wider range of textile products, through optimisation of blending with other traditional natural fibres (such as silk and linen). In addition, it is essential to specify the “conditions of validity”, including blend ratios, composting conditions, safety, and collection routes (e.g., industrial composting and municipal systems), and to verify the scope of application in a use-specific manner.
- **Application of Institutional Co-Design:** The “Institutional Co-Design” approach, which uses the CCM (contractor–merchant manufacturer) as a hub, is expected to be applicable to other regional industries in relation to Actor–Network Theory. This approach promotes incremental innovation by translating social and environmental values across the supply chain while maintaining traditional quality standards. However, the claim made here is conditional: rather than invoking ANT as a general theory, it suggests that redesigning specifications, roles, and responsibilities can function effectively in districts where a nodal actor such as the CCM exists as a point of quality assurance and contractual coordination.
- **Exploration of Designed Temporality:** The concept of “designed temporality” in clothing has the potential to develop into a design field focused on ethical ageing, in which changes in material over time (such as wear, decomposition, and fading) are actively incorporated as design elements. This can contribute to the establishment of new aesthetics and a consumption ethic within sustainable textile culture. At the present stage, however, this study does not claim to have optimised such changes as aesthetic design; instead, it articulates a design premise that includes potential future change (biodegradability). Future work needs to develop evaluation frameworks aligned with real conditions of use, storage, and disposal (service life, deterioration, and degradation behaviour), and to advance verification as an integration of aesthetics, operation, and ethics.

Finally, while the full-scale operationalisation of biodegradable polyester—particularly the establishment of stable warp-yarn operation and the coordination of process conditions and specification agreements—remains a future task, this study’s significance lies in clarifying the issues and institutional connection points through which the introduction of new materials can become viable within a traditional production district.

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Abbreviations

The following abbreviations are used in this manuscript:

CCM	contractor-cum-merchant
CGS	computer graphics system

References

- Barry, Ben. 2017. Encloded knowledge: The fashion show as a method of dissemination in arts-informed research. *Forum Qualitative Sozialforschung/Forum: Qualitative Social Research* 18: 3. [\[CrossRef\]](#)
- Bjögvinsson, Erling, Pelle Ehn, and Per-Anders Hillgren. 2012. Design things and design thinking: Contemporary participatory design challenges. *Design Issues* 28: 101–16. [\[CrossRef\]](#)
- Devendorf, Laura, Kathryn Walters, Marianne Fairbanks, Etta Sandry, and Emma R. Goodwill. 2023. AdaCAD: Parametric Design as a New Form of Notation for Complex Weaving. Paper presented at the 2023 CHI Conference on Human Factors in Computing Systems, Hamburg, Germany, April 23–28; pp. 1–18. [\[CrossRef\]](#)
- Devendorf, Laura, Katya Arquilla, Sandra Wirtanen, Allison Anderson, and Steven Frost. 2020. Craftspeople as Technical Collaborators: Lessons Learned Through an Experimental Weaving Residency. Paper presented at the 2020 CHI Conference on Human Factors in Computing Systems (CHI '20), Honolulu, HI, USA, April 25–30; pp. 1–13. [\[CrossRef\]](#)
- Entwistle, Joanne. 2015. *The Fashioned Body: Fashion, Dress and Social Theory*, 2nd ed. Cambridge: Polity Press.
- Entwistle, Joanne, and Agnès Rocamora. 2006. The field of fashion materialized: A study of London Fashion Week. *Sociology* 40: 735–51. [\[CrossRef\]](#)
- Etzkowitz, Henry, and Loet Leydesdorff. 2000. The dynamics of innovation: From national systems and “Mode 2” to a triple helix of university–industry–government relations. *Research Policy* 29: 109–23. [\[CrossRef\]](#)
- Fletcher, Kate. 2014. *Sustainable Fashion and Textiles: Design Journeys*, 2nd ed. Abingdon: Routledge.
- Gill, Simeon, Carol McDonald, Katy Schildmeyer, and Dana Todd. 2023. Building Novel Dynamic Pattern Theory via 3D Body Scanning Data. Paper presented at the 14th International Conference and Exhibition on 3D Body Scanning and Processing Technologies, Lugano, Switzerland, October 17–18. [\[CrossRef\]](#)
- Hashino, Tomoko, and Keiji Otsuka. 2013. Cluster-based industrial development in contemporary developing countries and modern Japanese economic history. *Journal of the Japanese and International Economies* 30: 19–32. [\[CrossRef\]](#)
- Haynes, Alice, and Jürgen Steimle. 2024. Flexiles: Designing Customisable Shape-Change in Textiles with SMA-Actuated Smocking Patterns. Paper presented at the 2024 CHI Conference on Human Factors in Computing Systems (CHI '24), Honolulu, HI, USA, May 11–16; pp. 1–17. [\[CrossRef\]](#)
- Holyoke, Julie. 2013. *Digital Jacquard Design*. London: Bloomsbury Publishing Academic.
- Jackson, Paul. 2015. *Complete Pleats: Pleating Techniques for Fashion, Architecture and Design*. London: Laurence King Publishing.
- Kawamura, Yuniya. 2023. *Fashion-Ology: Fashion Studies in the Postmodern Digital Era*, 3rd ed. London: Bloomsbury Publishing. [\[CrossRef\]](#)
- Koskinen, Ilpo, John Zimmerman, Thomas Binder, Johan Redström, and Stephan Wensveen. 2011. *Design Research Through Practice: From the Lab, Field, and Showroom*. Waltham: Morgan Kaufmann Publishers.
- Kyoto Modern Dyeing and Weaving Technology Development History Compilation Committee. 1990. *Kyoto Modern Dyeing and Weaving Technology Development History* [京都近代染織技術発達史]. Kyoto: Kyoto Municipal Center for Dyeing and Weaving.
- Latour, Bruno. 2005. *Reassembling the Social: An Introduction to Actor-Network-Theory*. Oxford: Oxford University Press. [\[CrossRef\]](#)
- Lawrence, Thomas B., and Roy Suddaby. 2006. Institutions and institutional work. In *The SAGE Handbook of Organization Studies*, 3rd ed. Edited by Stewart R. Clegg, Cynthia Hardy, Thomas B. Lawrence and Walter R. Nord. London: Sage Publications, pp. 215–54. [\[CrossRef\]](#)
- Loper, Matthew, Naureen Mahmood, Javier Romero, Gerard Pons-Moll, and Michael J. Black. 2015. SMPL: A skinned multi-person linear model. *ACM Transactions on Graphics* 34: 248. [\[CrossRef\]](#)
- Manzini, Ezio. 2015. *Design, When Everybody Designs: An Introduction to Design for Social Innovation*. Cambridge: MIT Press. [\[CrossRef\]](#)
- Narumi, Koya, Kazuki Koyama, Kai Suto, Yuta Noma, Hiroki Sato, Tomohiro Tachi, Masaaki Sugimoto, Takeo Igarashi, and Yoshihiro Kawahara. 2023. Inkjet 4D print: Self-folding tessellated origami objects by inkjet UV printing. *ACM Transactions on Graphics* 42: 117. [\[CrossRef\]](#)
- Pietroni, Nico, Corentin Dumery, Raphael Falque, Mark Liu, Teresa Vidal-Calleja, and Olga Sorkine-Hornung. 2022. Computational pattern making from 3D garment models. *ACM Transactions on Graphics* 41: 157. [\[CrossRef\]](#)
- Rissanen, Timo, and Holly McQuillan. 2016. *Zero Waste Fashion Design*. London: Bloomsbury Publishing.
- Sato, Daisuke, Yuichi Ikeda, Shuichi Kawai, and Maximilian Schich. 2020. The sustainability and the survivability of Kyoto's traditional craft industry revealed from supplier–customer network. *PLoS ONE* 15: e0240618. [\[CrossRef\]](#) [\[PubMed\]](#)

- Sennett, Richard. 2008. *The Craftsman*. New Haven: Yale University Press.
- Ueda, Kaori, and Milou Voorwinden. 2022. The innovative development of the Jacquard weaving machine in Japan. *The Journal of the Asian Conference of Design History and Theory* 4: 62–73.
- Vahid, Daniela Ghanbari, Lee Jones, Audrey Girouard, and Lois Frankel. 2021. Shape Changing Fabric Samples for Interactive Fashion Design. Paper presented at the Fifteenth International Conference on Tangible, Embedded, and Embodied Interaction, Salzburg, Austria, February 14–17; pp. 1–7. [[CrossRef](#)]
- Zhang, Ruowang, Stefanie Mueller, Gilbert Louis Bernstein, Adriana Schulz, and Mackenzie Leake. 2024. WasteBanned: Supporting Zero Waste Fashion Design Through Linked Edits. Paper presented at the 37th Annual ACM Symposium on User Interface Software and Technology (UIST '24), Pittsburgh, PA, USA, October 13–16; pp. 1–13. [[CrossRef](#)]

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