Fecha de recepción: enero 2026
Fecha de aprobación: marzo 2026

Creative practices and design tools for the development of technological textiles: exploring the experimental transmedia process

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Abstract: This research investigates creative practices and design tools that foster innovation in the development of technological textiles, focusing on how creativity emerges within experimental transmedia contexts. The study examines the procedures, tools, and methodologies that enhance both the conceptual and material phases of textile design when art, design, and digital technologies intersect. By analyzing the creative process, the research aims to assess how experimental and technological approaches transform traditional design logic into multisensory and interactive experiences. These experiences transcend conventional communication structures, engaging audiences as active participants in open, non-linear narratives. Using a qualitative, exploratory approach, the project examines how tools such as generative design software, digital fabrication, and interactive materials contribute to the development of hybrid textile artifacts that embody both aesthetic expression and technological functionality. The study highlights how these practices can redefine the designer's role as creator and researcher within a transmedia laboratory of meaning. Ultimately, this investigation seeks to contribute to an understanding of creativity as a dynamic and systemic process, in which experimentation and speculation become essential for reimagining the future of textile design in the digital age.

Keywords: Technological textiles - Creative process - Design tools - Transmedia experimentation - Digital fabrication - Hybrid design - Interactive materials - Creative practices - Art and technology - Design innovation

[Resúmenes en español y en portugués en las páginas 300-301]

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Introduction

Transmedia design constitutes a projectual approach that integrates multiple media, platforms, and languages to construct expanded, coherent, and interactive experiences. Unlike the simple replication of content across different channels, this approach proposes the creation of a narrative universe in which each medium contributes new layers of meaning, allowing the experience to be deepened, explored, and collaboratively reconstructed by users (Altamirano, 2019).

Traditional textile design typically follows linear pathways; however, technological textiles demand the integration of computing, electronics, and materials science. Within this context, transmedia design introduces models for narrative experiences that are significantly more complex and interactive. This intersection remains underexplored. There is a notable

gap in understanding how the designer's creative process shifts when the goal is not merely to create something functional or aesthetically pleasing, but to develop a hybrid artifact that operates as an interface for a multisensory and transmedia narrative experience.

This research is fundamental for developing new design methodologies that respond to the complexity of contemporary physical-digital artifacts. The overarching objective of this study is to understand how an experimental transmedia framework reshapes methodologies, tools, and creative practices in the design of technological textiles. The guiding question concerns how design practices and tools, when applied within an experimental transmedia context, transform traditional textile design, enabling the creation of hybrid artifacts and interactive experiences.

Technological textiles, often referred to as smart textiles, represent a significant evolution within the textile industry, surpassing traditional protective and aesthetic functions. These materials are defined by their ability to interact with the environment and respond to external stimuli that may be mechanical, thermal, chemical, electrical, or magnetic in nature (Antunes & Cabral, 2016).

A particularly relevant branch within this field is that of e-textiles (electronic textiles), which enable the incorporation of components such as sensors, batteries, and microcontrollers directly into the fabric's structural mesh (Silva, 2022). This integration represents a significant advancement in the development of wearable systems that combine textile substrates with electronic functionalities, enabling real-time monitoring and actuation (Gomes & Cândido, 2020).

Accordingly, this study aims to identify creative practices emerging from transmedia explorations in textile design and to investigate the impact of digital tools and electronic platforms on the conception of hybrid artifacts. Furthermore, the research seeks to understand how experimental design distinguishes itself from traditional approaches by considering processes, collaboration, and intended outcomes.

The investigation into creativity and consumption habits in the textile sector was conducted from a qualitative perspective, adopting an exploratory and descriptive stance supported by a theoretical–empirical approach. The findings reveal non-linearity, reflecting the logic of media convergence and the interactivity inherent in technological artifacts, wherein creation, testing, narrative development, and participation occur simultaneously and mutually reinforce one another. This breaks with traditional linearity to address the complexity of multisensory hybrid artifacts.

Theoretical framework

Product design within the textile sector is a systematic process that encompasses stages ranging from initial research to final production. The planning phase is fundamental, as it structures projectual actions and guides the team toward meeting market demands (Bastos, Ribeiro, Cunha, Lima & Cardoso, 2023). The development of fashion collections, therefore, combines planning, research, and execution, articulating creative and productive aspects in an integrated manner.

According to Bastos *et al*. (2023), planning plays a central role in organizing projectual actions and directing the process toward fulfilling market expectations. The authors further highlight that the development of original fabrics is decisive for strengthening brand identity and generating symbolic value. While functional limitations may restrict innovation in garment silhouettes, fabrics become the primary creative field for differentiation, particularly within the context of fast fashion.

This process involves both macro-level stages, such as defining concepts and strategies, and more detailed activities, including material selection and prototyping (Moretti & Braghini, 2017). Silva and Rupasinghe *et al.* (2016) argue that development should be iterative, incorporating market information and stakeholder participation. Barnes *et al*. (2017) reinforce that planning ensures cohesion among stages, while prototyping allows for technical and market validation of the product.

Material selection, especially that used in fabrics, is decisive for product success, defining aesthetic and functional characteristics that influence market acceptance (Cietta, 2017; Parker-Strak *et al*., 2020). However, little has been discussed about how traditional companies articulate creative tools to overcome the replication of patterns widely disseminated in the market.

The textile sector faces the ongoing challenge of balancing creative innovation with the demands of a market characterized by accelerated consumption cycles, particularly within the logic of fast fashion (Maciel & Barbosa, 2025). Authorial innovation is frequently constrained by structural factors within the production chain, such as minimum scale requirements and cost pressures, which restrict the creative freedom of designers (Dias & Colombo, 2021). Consequently, many companies prioritize trend forecasting and adjust their processes to market predictability, resulting largely in incremental rather than radical innovation (Gual-Ortí *et al*., 2025).

Authorial creativity, when it does emerge, often manifests in the "gaps within the process," such as research trips or attempts to incorporate cultural narratives. Nevertheless, it remains limited by the logic of efficiency and scale (Hoffmann, 2025). Within this scenario, technological textile design has increasingly investigated how experimentation, digital tools, and the integration of electronic platforms can break with the linearity of traditional processes (Bastos *et al*., 2023; Figoli *et al*., 2022). The introduction of generative design software, digital fabrication, and smart materials enables the expansion of the design repertoire and the exploration of hybrid artifacts that relate to multisensory and narrative experiences (Chakraborty *et al*., 2025; Gong *et al*., 2024).

This perspective stimulates speculative and collaborative practices (Berg *et al*., 2021). Experimental transmedia design, in this context, offers pathways for rethinking products, processes, and roles, suggesting approaches that extend beyond the aesthetic and functional functions of artifacts, fostering engagement and meaning in the digital age (Dawood & Ali Elfa, 2023; Kwon *et al*., 2023).

Creativity, ideation, and flexible methodologies

Creativity may be understood as the capacity to generate original and useful ideas or artifacts, manifesting through four dimensions: novelty, flexibility, quality, and quantity (Garcês *et al*., 2021). In textile design, overcoming the replication of commercial patterns requires flexible methodologies capable of integrating authorial innovation with market demands (Maciel & Barbosa, 2025).

Flexibility enables the incorporation of creative tools into commercial contexts without compromising originality (Dias & Colombo, 2021). Ideation practices or conceptual design are essential, as they involve the search for innovative solutions and the rupture of design fixation, a phenomenon in which prior experiences limit creative exploration (Chakraborty *et al*., 2025).

Idea generation may be stimulated by techniques such as brainstorming, morphological analysis, and the MESCRAI method (Modify, Eliminate, Substitute, Combine, Rearrange, Adapt, Invert), all of which expand the solution space (Bastos *et al*., 2023). Interdisciplinary collaboration is equally crucial, given the collective nature of the creative process in the textile industry (Berg *et al*., 2021).

The use of speculative scenarios constitutes another powerful strategy, enabling designers to anticipate desirable futures and develop materials that express long-term visions and emerging cultural values (Hoffmann, 2025; Kwon *et al*., 2023).

The incorporation of such practices enriches the design repertoire and encourages experimentation with materials, processes, and emerging technologies, generating original solutions and unique identities within the sector. Divergent thinking and rapid prototyping broaden the variety of alternatives and render the creative process more dynamic and adaptive to market changes. Designers, therefore, move beyond mere functionality, articulating multisensory and narrative experiences aligned with contemporary visual culture.

Generative Artificial Intelligence (GAI) reinforces this movement by creating new content and optimizing workflows, thereby advancing innovation (Hessel & Lemes, 2023). However, its use must be guided by cultural and experimental practices that ensure technology enhances rather than replaces creative expression grounded in symbolic and identity-based references.

In short, the intersection between art, design, and digital technologies, particularly Generative AI, is profoundly transforming contemporary creative logic. Creativity, although considered one of the competencies least susceptible to replacement by AI, is being redefined by technology. In this context, innovation emerges precisely at the convergence of creativity and technology (Cerqueira, 2024).

Transmedia structure and visual culture

Introducing an experimental transmedia context into textile design invokes the interface between art, fashion, and visual culture, proposing an exploration of the product beyond its physical functionality.

Fashion may be understood as a form of visual art and a cultural device that mobilizes social strata by reflecting values, identities, and lifestyles typical of hyperconsumption. The dialogue between art and fashion is historical, manifesting in concepts such as the Künstlerkleid ("artist's garment"). Fabric itself becomes the primary creative field for product differentiation and the generation of symbolic value (Berg, Vestena & Costa-Lobo, 2021).
Visual Culture and Experiences: Visual Culture is a transdisciplinary field that examines the role of images in shaping subjectivities and mediating relationships with the world. Artifacts such as clothing, costumes, and artistic objects convey meanings and experiences that reveal the centrality of visual culture. The proposal of creating interactive experiences aligns with the notion that design extends beyond the creation of objects to encompass interactions, systems, and environments (Berg, Vestena & Costa-Lobo, 2021; Chakraborty, Loyens & Aston, 2025).

Complexity, feeling and thinking

Theories of Complexity and Transdisciplinarity provide the framework for this experimentation by challenging the fragmentation of knowledge. Transdisciplinarity articulates reason, emotion, and transformative attitudes, seeking thinking-feeling as an essential attribute of human consciousness and knowledge construction. From this standpoint, creativity is understood as a transdisciplinary phenomenon involving object, subject, and process.
Within this scenario, the transmedia structure in textile design emerges as a fertile platform for the convergence of diverse fields of knowledge. It promotes the creation of artifacts that engage multiple visual and narrative codes, expanding the reach of creativity beyond conventional limits.
By recognizing visual culture as a central element, designers begin to explore hybrid languages and integrate artistic, technological, and social references into product development, enhancing interactive and sensory experiences that reframe the role of textile materials. This process is enriched by the adoption of transdisciplinary approaches that articulate logical reasoning with sensory and emotional experience, fostering innovative proposals that connect textile design with art, fashion, and technology.
Transmedia experimentation combined with openness to complexity and the thinking-feeling paradigm lays the groundwork for the integration of new creative tools, such as Generative Artificial Intelligence, which acts as a catalyst for lateral thinking and the production of hybrid artifacts. In doing so, it expands the repertoire of possibilities and consolidates textile design as a strategic field for the development of meaningful, authorial experiences in contemporary contexts (Dawood & Ali Elfa, 2023).

The integration of artificial intelligence and the emergence of the hybrid

The transmedia and hybrid dimension is strengthened by the adoption of Generative Artificial Intelligence (GAI) tools. AI is viewed as an auxiliary or co-creative instrument capable of transforming the design workflow.

Generative AI can significantly enhance creative efficiency and productivity. It can rapidly generate a large volume of diverse content (texts, images, 3D models), functioning as an inspirational stimulus. Its unpredictability acts as a catalyst for lateral thinking and helps break design fixation. Moreover, AI tools can inspire designers with compelling suggestions when they are creatively blocked (York, 2025).

During AI-supported design processes, the role of the designer shifts from creator to evaluator and optimizer, the Designer Arbiter. This collaboration between human intuition and computational power is essential. In experimental and transmedia contexts, AI can be used to generate complex visualizations (text-to-image) and refine conceptual ideas.

Mixed or hybrid methods represent the most effective strategy, as they combine organic human creativity (manual sketches, contextual knowledge) with AI's synthetic creativity. The blending technique allows designers to integrate AI-generated visual elements with their initial concepts while maintaining authorship and creative control. Blending has proven effective for breaking design fixation and producing viable, innovative proposals, especially for new products. This collaboration is continuous: the machine generates acceptable and interesting outcomes only to the extent that the prompt is well crafted by human intelligence (Hessel & Lemes, 2023).

By integrating Generative AI tools into the textile design workflow, the transmedia and hybrid dimension grows stronger, as these technologies act as catalysts for creative alternatives and expand the repertoire of original solutions.

Generative AI is a tool dedicated to creating new solutions and content, but always based on information previously conceived by human minds and stored in extensive databases (Hessel & Lemes, 2023). AI functions as a reliable assistant, supporting the entire creative process and workflow, aiding in the conceptualization of ideas and the structuring of design strategies (York, 2025).

Thus, AI not only transforms the designer's role, positioning them as evaluator and integrator but also enhances the generation of complex visualizations and conceptual refinement, especially in experimental and collaborative environments. The blending technique, by merging AI-generated synthetic creativity with the organic nature of hand sketches and contextual knowledge, enables the emergence of hybrid artifacts that transcend the traditional boundaries of textile production.

The synergy between human and computational processes, therefore, results in innovative and authorial proposals, supporting the transformation of traditional textile design into an experimental transmedia process. Continuing along this trajectory, the intersection of art, design, and digital technologies such as Generative AI leads to a fundamental restructuring of creative logic. This transformation is driven by cultural convergence, which emphasizes the continuous flow of content across multiple media channels (Jenkins, 2008).

In summary, transforming traditional textile design into an experimental transmedia process requires recognizing the limits of mass production, the need for flexible methodolo-

gies, and the potential of AI as a creative catalyst. The expected outcome, the emergence of hybrid artifacts and interactive experiences, derives from the synergy between human creativity (vision, ethics, judgment) and AI efficiency (volume, speed of ideation).

Transmedia framework

The experimental transmedia framework consists of a conceptual and methodological structure that guides the creative process in contemporary design. Transmedia language, characterized by its complex, dynamic, and open nature, requires that design projects be structured to promote participation, connection, and expansion across multiple levels (Altamirano, 2019). In this sense, the framework redefines design practices by demanding comprehensive, participatory, and integrated approaches (Altamirano, 2019).

For Generative AI to produce results that align with the requirements of a transmedia project, the content of the prompt must be specific and detailed, directly influencing the quality and relevance of the generated outputs (Hessel & Lemes, 2023). Structuring AI inputs depends fundamentally on human intelligence to guide the process.

Thus, the multifactorial and multivariate nature of transmedia systems (Galán, 2012) requires that prompts include not only simple commands but also detailed contextual information, desired stylistic directions, and specific constraints (Hessel & Lemes, 2023). More elaborate commands significantly improve the results (Röhe & Santaella, 2023).

Furthermore, applying the transmedia framework to technological textile design, which implies diversifying a narrative or product across multiple media and platform,s enhances projectual value. Consequently, the prompt becomes the mechanism through which transmedia elements such as expansion, seriality, and multiplicity (Jenkins, 2009), as well as narrative production parameters such as gamification and multiplatform structures (Galán, 2012), are translated into clear technical instructions for AI.

Within this context, the framework reconfigures design practices by requiring a complex, holistic, dynamic, participatory, inclusive, and integrated approach (Altamirano, 2019).

Methodology

This research adopts a qualitative, exploratory approach, which is appropriate for examining complex and subjective phenomena associated with the creative process in the design of technological textiles. Grounded in the understanding that qualitative studies seek to interpret meanings (Severino, 2017) and that creativity manifests through cultural and cognitive interaction with the environment (Vygotsky, 1988), the research privileges the contextualization of participants' experiences.

The hybrid nature of the artifacts situated at the intersection of art, technology, and fashion demands flexible methods capable of capturing multiple layers of meaning (Wilson, 1985). Accordingly, this study is structured as exploratory research aimed at identifying innovative

practices and analyzing the underlying logic of hybrid artifact conception. It is supported by contemporary perspectives that emphasize the importance of experimentation, interdisciplinarity, and co-creation in highly complex contexts (Knudsen *et al*., 2025). Consistent with this approach, the study prioritizes contextual interpretation of the data, recognizing that creative behavior involves symbolic and cultural dimensions (Solomon *et al*., 2022).
The study was conducted based on the Design Science Research Methodology (DSRM), as proposed by Peffers *et al*. (2007), in articulation with the principles of Research Through Design. The adoption of DSRM is justified by its suitability for the development, prototyping, and evaluation of artifacts in this case, a methodological framework aimed at integrating Artificial Intelligence (AI) into the design process. The investigation followed the six stages defined by DSRM, as described below.

Problem identification
The initial stage consisted of an exploratory analysis of the field of contemporary design, focusing on limitations observed in the application of AI within creative processes. Two complementary sources were used:

(a) Interactions mediated by generative AI, which supported the formulation of the design challenge, the elaboration of How Might We questions, and stakeholder mapping (Santis *et al*., 2025);
(b) A preliminary literature review, which revealed methodological gaps in AI integration, such as technological dependence, cognitive overload, and the absence of structured guidelines for ideation, definition, and prototyping (Kim & Maher, 2023; Kwon, Rao, & Goucher-Lambert, 2023; Gong *et al*., 2024; Yu, 2025).

This stage enabled the formulation of the central problem: the absence of a structured framework to guide textile designers in using AI strategically and not merely superficially throughout the phases of the design process.

Definition of research objectives
Based on the previous stage of the study, the objectives guiding this investigation were delineated. The general objective is to develop an evidence-based operational framework to support the integration of Artificial Intelligence (AI) into the textile design process.
Complementarily, the following specific objectives were established:

- To map recent evidence regarding AI applications in the field of design.
- To identify the roles, risks, and potentialities of collaboration between humans and AI systems;
- To design and prototype the proposed methodological artifact;
- To evaluate the theoretical coherence and practical applicability of the developed framework.

These objectives were refined with the support of large language models (LLMs), in alignment with Research Through Design (RTD) practices, which emphasize experimentation and the iterative construction of artifacts as a means of producing knowledge (Altamirano, 2019; Amaral, 2023).

Artifact design and development

The development of the artifact unfolded along two complementary fronts:

a) *Oriented Systematic Review (OSR):* The review, recorded in the *Notebook LM* file, included articles published in the last five years addressing the practical application of AI in different phases of the design process. Experimental studies, workshops, case studies, and theoretical reviews were included (Bastos *et al.*, 2023; Figoli, Mattioli, & Rampino, 2022; Chandrasekera, Hosseini, & Perera, 2024; Yu, 2025). The articles were organized according to the stage of the design process in which AI was applied ideation, research/definition, development/prototyping, and complete workflows, allowing the identification of usage patterns and success criteria.

b) *Progressive Prototyping:* Based on the synthesis of the review, prototypes of the framework were developed (*Prototyping - Framework Design Construction Agent* file), including use hypotheses, success criteria, value maps, human–AI interaction structures, and preliminary methodological flows. This stage culminated in the consolidated version of the Human–AI Co-Design Framework, which integrates phases, artifacts, AI roles, designer roles, and evaluation metrics.

Demonstration

The framework was demonstrated through:

a) Simulated applications in real design scenarios;
b) Comparison with existing methodologies, such as Design Thinking, the Double Diamond model, and Product Design processes;
c) Internal consistency analyses, verifying alignment among phases, roles, and objectives.
The demonstrative scenarios were documented in the prototyping materials and in the slides presenting the Human–AI Co-Design Framework.

Evaluation

The evaluation followed two main criteria:

a) *Theoretical–methodological coherence*
The framework was compared with findings from the literature to verify whether it incorporated recommendations such as:

- Use of conceptually similar inspiration (Kim & Maher, 2023);
- Human–AI mediation to avoid design fixation (Chandrasekera *et al.*, 2024);

- Balance between individual and collective ideation (Gong *et al*., 2024);
- The designer's role as Arbiter/Integrator (Yu, 2025);
- Need for decision-making artifacts and metrics (Bastos *et al*., 2023).

b) *Operational evaluation*

The following aspects were analyzed: clarity and hierarchy of phases, fluency between stages, robustness of generated artifacts, and applicability across different design domains. The results indicated that the artifact met the initial requirements and overcame limitations observed in current methodologies.

Communication of results

The final stage consisted of systematizing knowledge into:

a) *Visual explanatory materials;*
b) *Functional prototypes of the methodological structure.*

This stage fulfills the DSRM guideline of disseminating the artifact and its foundations to the scientific and professional communities.

According to Knudsen *et al*. (2025), innovation in complex environments depends on continuous processes of learning and reconstruction of meaning a principle that underpins the iterative nature of this stage.

Results and discussion

Interaction with Artificial Intelligence (AI) in textile design transcends mere technical application, constituting a transdisciplinary approach that integrates critical thinking, aesthetic sensitivity, and experimentation. AI operates as a cognitive mediator, expanding the creative repertoire and stimulating lateral thinking without replacing human intuition or authorship (Altamirano, 2019; Amaral, 2023).

In this context, AI contributes as an assistant within the creative workflow, automating repetitive tasks and providing support for ideation, human–AI blending, hybrid materialization, and sensory evaluation. Based on PRISMA-P guidelines and practical tests, a non-linear framework was developed that integrates art, technology, and transmedia narrative, structuring the process into iterative cycles of speculation, experimentation, and feedback. The results indicate that AI enhances idea generation and conceptual development; however, authentic creativity remains centered on the human element, which critically and sensitively directs the integration of digital technologies into contemporary textile design. The Non-Linear Framework of the Creative Process in Textile Design, presented in *Figure 1*, organizes design phases within a context of human–AI co-creation and transmedia experimentation. Unlike traditional linearity (research → concept → production), the model presents an iterative cycle in which speculation, technology, and sensory evaluation mutually reinforce one another, promoting greater flexibility and innovation in the creative process.

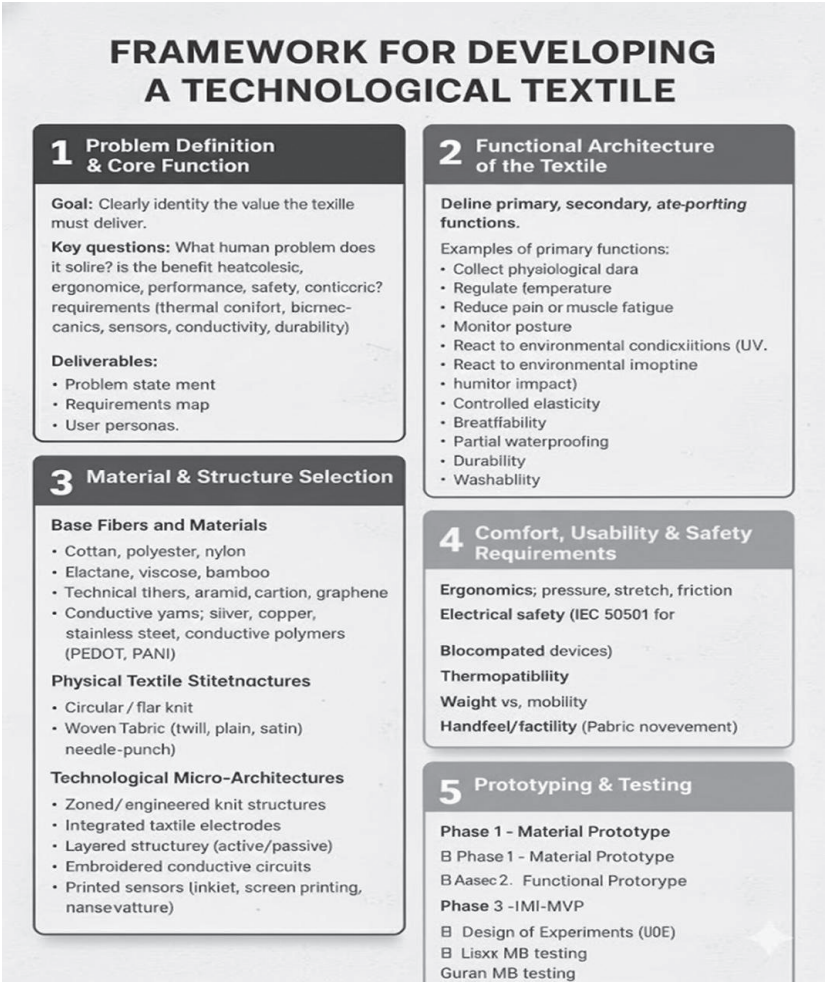

Figure 1. Framework. *Figure 1* presents the framework of the creative process in textile design with Artificial Intelligence (AI) interaction, structured into four interdependent stages that highlight the collaboration between the designer and generative AI systems.

The first stage, ideation and conceptualization, corresponds to the initial problem definition and the generation of multiple conceptual proposals, in which AI functions as a supportive agent for brainstorming. At this stage, AI enhances divergent exploration and the mapping of visual, cultural, and narrative references.

The second stage, human–AI blending, is characterized by hybrid authorship, in which the designer assumes the role of critical curator, refining and integrating AI-generated elements with human contributions to ensure originality and symbolic coherence.

The third stage, materialization and prototyping, consists of translating concepts into physical and functional artifacts through the integration of digital technologies and textile materials, resulting in multisensory prototypes.

Finally, the transmedia evaluation and iteration phase involves sensory and narrative validation supported by the collection of qualitative feedback, which feeds back into the creative process and consolidates the studio as a speculative and transmedia environment. This model reveals the non-linear and iterative nature of contemporary design, in which art, technology, and narrative converge to produce hybrid and interactive experiences.

Continuing, in contrast with research that emphasizes the relevance of transmedia and platform convergence for the construction of more complex narratives, the taxonomy serves as a means of structuring the dialogue between new technological dynamics and traditional design practices, fostering methodological clarity and innovation (Silva, 2021; Zhang & Li, 2022; Costa & Pereira, 2019).

The Taxonomy of Hybrid Tools for Textile Design provides a system for cataloging and describing how advanced tools such as generative design and digital fabrication are being hybridized and adapted by designers to create technological functionality and aesthetic expression simultaneously *(See Table 1).*

Table 1. Taxonomy of Hybrid Tools for Textile Design (Source: Author, 2025).

Category	**Subcategory**	**Technological Functionality**	**Aesthetic Expression**	**Examples**	**Authors**
I. Generative Design and AI Tools Devices as Intermediaries (high autonomy)	A. Personalized Design Systems	Precise capture of body measurements (digital twins); automatic body-specific pattern adaptation	Custom fit; reduction of material waste	SXD AI (reduces waste by up to 46%)	SXD AI, 2023
	B. Generative Adaptive Patterns	Automatic adjustment to sizes, shapes, and fabrics	Creation of unique patterns without manual intervention	Platforms that accelerate weeks of work	Zhang & Li, 2022
	C. Material Optimization	Algorithms for efficient pattern placement; creative use of scraps and recycled materials; fiber direction analysis	Enhances sustainability and visual layout	Optimization tools	Silva, 2021
II. Virtual Prototyping Systems (Industry 4.0) Devices as Tools (dependent on human actor)	A. 3D Modeling Software	Simulation of drape and fit; garment behavior prediction	Realistic visualization of textures, colors, and structural details	Accumark V-Stitcher, Browzwear, Optitex, Lectra, Audaces 3D, Clo 3D	Gerber Technology, 2020; Browzwear, 2021; Lectra, 2022; Audaces, 2023; Clo Virtual Fashion, 2023
	B. Textile Property Simulators	Prediction of fabric mechanics; testing of color, texture, and deformation	Simulation of woven (0/90°), knitted, and nonwoven structures	Digital fabric simulators	Müller & Schmidt, 2020

III. Textile Structure Hybridization Techniques Devices as Tools (requiring human expertise)	A. Veil/Fabric Combination Systems	Integration of layers with distinct mechanical and tactile properties	Complex visual effects through overlay and transparency	Hybrids combining needle-punched nonwovens and woven fabrics	Costa & Pereira, 2019
	B. Adaptive Needlepunching Techniques	Seamless joining of textile structures	Creation of 3D patterns and tactile textures	Adjustable parameters: number of passes, layering, needle density	Yamamoto, 2021
IV. Hybrid Digital Fabrication Systems Devices as Intermediaries (increasing autonomy)	A. Hybrid Production Technologies	Integration of traditional and digital manufacturing techniques	Generation of patterns unattainable through conventional methods	Knitting combined with digital material deposition	
	B. Programmable Weaving Systems	Precise control of patterns and woven structures	Smooth gradients and structural transitions; 2D/3D/DOS alternation	Programmable looms	Yamamoto, 2021

The present taxonomy proposes a systematization of emerging hybrid tools in the field of textile design, grounded in an analysis of the technological and methodological advances that have been redefining creative and productive processes. Structured into four major categories, this taxonomy encompasses devices with varying degrees of autonomy and different levels of integration between aesthetics, functionality, and digital innovation. The interactive relationships are presented in *Table 2*.

Table 2. Interactive Relationships in the Taxonomy (Source: Author, 2025).

Aspect	**Description**
Information Flow	Generative design → Virtual prototyping → Hybridization → Digital fabrication
Feedback Cycle	Outputs from fabrication feed back into generative design systems
Level of Autonomy	From designer-dependent tools to systems with autonomous decision-making
Vertical Integration	From aesthetic conception to functional optimization

These tools operate with high autonomy, functioning as intermediary devices that facilitate personalized design and material optimization.
One of the outcomes of integrating design and Artificial Intelligence (AI) was the creation of a textile design agent configured to guide the development of advanced technological fabrics. This agent functions as a strategic support system, providing guidelines for the conception of innovative and functional materials aligned with contemporary demands for performance, comfort, and sustainability (Hessel & Lemes, 2023; York, 2025).

Primary functionalities
Technological textiles must incorporate essential functionalities, both active (responsive to external stimuli) and passive (intrinsic to the material). Among these are:

- Thermal regulation and breathability;
- Resistance to water, stains, and abrasion;
- Elasticity, compression, and ergonomic fit;
- Protection against ultraviolet (UV) radiation;
- Biometric monitoring and electrical conductivity for wearable applications.

These functionalities broaden the scope of use across different contexts, reinforcing AI's role as a mediator in both the creative and productive processes (Cerqueira, 2024).

Performance and application requirements
The definition of the primary application guides the technical requirements of the textile. Possible contexts include:

- High-performance sportswear;
- Workwear with specific protective features;
- Smart urban fashion;
- Functional home textiles;
- Medical applications and wearable devices.

For each application, factors to be considered include durability, abrasion resistance, ease of maintenance (washing and drying), as well as appropriate weight and bulk. Technical standards and specific certifications must also be observed to ensure regulatory compliance and product quality (Moura, 2005).

Association of innovative materials
The combination of fibers and materials is fundamental to achieving the desired functionalities:

- Natural fibers: organic cotton, linen, and bamboo, which offer sustainability, pleasant touch, and breathability.
- Advanced synthetic fibers: recycled polyester, high-tenacity nylon, and elastane, which contribute durability, elasticity, and strength.
- Smart/functional materials: conductive polymers, optical fibers, PCM (Phase Change Materials), hydrophilic/hydrophobic membranes, and nanoparticle treatments, which enable thermoregulation, sensing, and repellency.
- Textile structures: woven fabrics, knits, nonwovens, and 3D knits, which optimize drape, compression, and breathability.

The structure of the fabric, including weave, density, and finishing techniques, enhances the properties of the materials, increasing their functional efficiency (Rocha & Bandeira, n.d.).

Ergonomic and comfort benefits
The textile design agent should guide the creation of fabrics that maximize user comfort and performance, considering:

- Hand and tactile sensation: softness, roughness, or cooling effect on the skin.
- Drape and mobility: elasticity and structural behavior that support freedom of movement and ideal fit.
- Moisture management: ability to wick sweat and dry quickly, avoiding thermal discomfort.
- Weight and bulk: directly influencing usability and garment comfort.
- Reduction of friction/irritation: minimizing pressure points and skin abrasion.
- Thermal comfort: maintaining optimal body temperature under varying environmental conditions.

These aspects reinforce the importance of integrating design, ergonomics, and technology, consolidating AI's role as a catalyst for innovation in the textile sector *(See Figure 2)*.

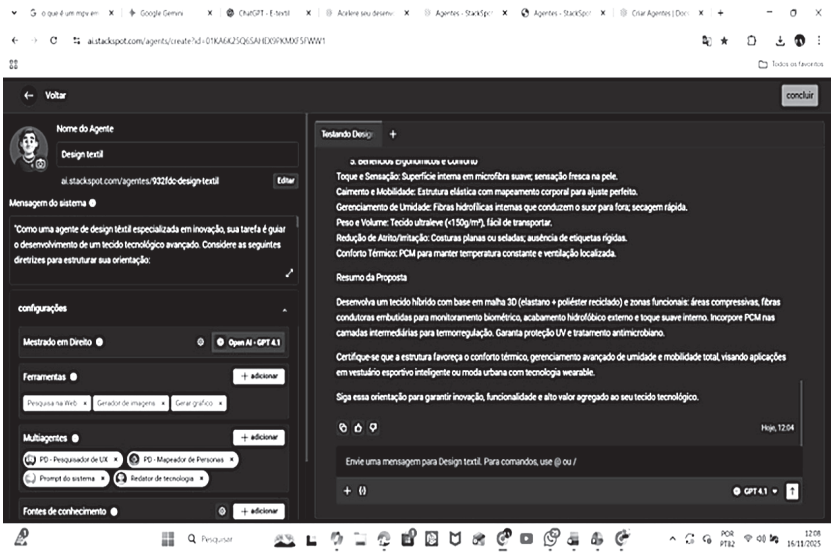

Figure 2. Textile Design Agent (Source: https://ai.stackspot.com/agents/01KA6K25Q6SAHEX9PKMXF5FWW1).

An Artificial Intelligence (AI)-based textile design agent supports the development of technological fabrics by acting as a mediator between creative demands and the technical requirements of the project. This agent is capable of structuring complex processes, providing strategic support at different stages of conception and production. It identifies and organizes the essential properties that the fabric must exhibit, such as thermal regulation, breathability, water resistance, elasticity, or electrical conductivity, ensuring that the material is designed in accordance with specific functional needs (Hessel & Lemes, 2023). Another solution identified is the WeaverAI platform, an AI-driven system that transforms ideas into production-ready textile patterns with speed and precision, aiming to enhance efficiency, innovation, and competitiveness in the textile sector. Its main benefits include:

- Rapid Generation: Creates original patterns (from text/images) and extracts/digitizes existing patterns in high resolution (300 DPI) within seconds.
- Flexibility: Allows advanced customization of colors, styles, and structures.
- Cost Reduction: Automates workflow and minimizes the need for physical prototyping.
- Integration: Provides digital outputs compatible with manufacturing systems, accelerating the transition from design to production.

High-Performance technological fabric proposal for elite sportswear
The proposed framework generated a detailed proposal integrating the required functionalities, materials, and ergonomic benefits specified.

--Considering the essential functional requirements, the proposed fabric must deliver high-performance characteristics suitable for elite athletic environments:
a.-Functionalities: adaptive thermal regulation, superior breathability, effective UV protection
b.- Durability: water resistance, stain protection, and abrasion resistance.
c.- Ergonomic Performance: controlled elasticity, optimized compression, perfect ergonomic fit.

--Considering the Required Base Materials:
a.- Fibers: recycled polyester, high-tenacity Nylon, and elastane.
b.- Functional Materials: PCM (Phase Change Materials), nanoparticle treatments for repellency, antimicrobial activity, enhanced sensing potential (IoT textiles).

--Considering the three options, the proposed textile structures:

a.- Option 1: Circular Knit (High Elasticity + Breathability)
Why ideal:
- Naturally stretchable structure ideal for compression mapping and form-fitting zones.
- Excellent breathability due to looped construction.
- Can integrate targeted mesh zones for ventilation and localized cooling.

b.- Option 2: Double-Layer Woven Fabric (Thermal + Protective Performance)
Why ideal:
Exceptional dimensional stability for embedding PCM microcapsules.
High durability and abrasion resistance are crucial for high-performance garments.
Structural density supports UV protection and nanoparticle adherence.

c.- Option 3: 3D Knit (Ergonomic Sculpting + Adaptive Comfort)
Why ideal:
- Enables body-mapped compression zones with varying thickness and density.
- Allows integration of channels for ventilation and thermal regulation.
- Produces seamless, ergonomic, low-friction garments optimal for elite performance.

Based on the given prompt, WeaverAI generated a technologically advanced fabric sample shown in *Figure 3.*

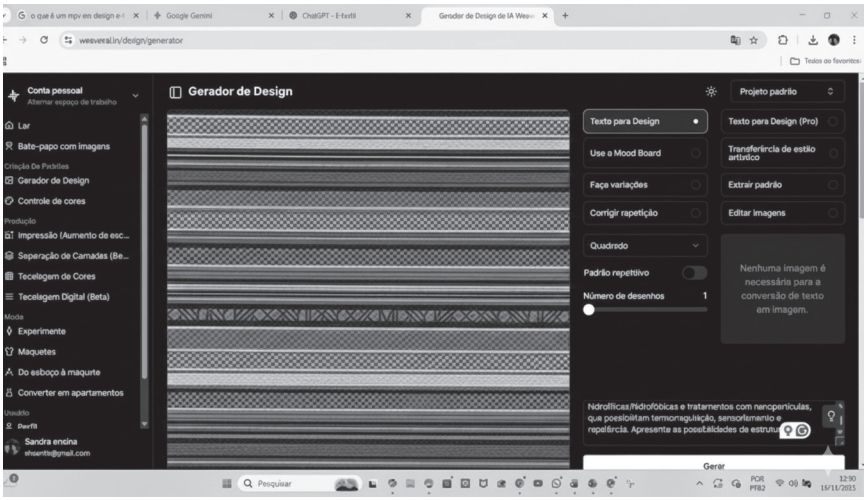

Figure 3. Technological Fabric Generated from Prompt (Source: https://weaverai.in/design/generator).

Figure 3 illustrates the advanced usability of the Weave.ai Design Generator, showing a fully rendered textile pattern in its central workspace, accompanied by a tool panel configured for generating new designs. These can be created from textual descriptions, mood boards, or AI-driven variations. The interface is specifically designed for the automated creation of textile patterns, highlighting the potential of Artificial Intelligence in optimizing creative and productive processes.

Final considerations

This investigation demonstrates that innovation in the development of technological textiles requires breaking with the linear logic of traditional design and transitioning toward a hybrid, systemic, and transmedia creative process. The main conclusion is that authorial creativity and technological innovation converge through a Non-Linear Framework capable of integrating art, technology, and narrative within a single process.

First, the emergence of the hybrid becomes evident, in which the focus of design shifts from creating purely aesthetic or functional products to developing hybrid artifacts that function as interfaces for multisensory and interactive narrative experiences.

Second, authorship undergoes a redefinition, as Generative Artificial Intelligence (GAI) does not replace the designer but instead transforms them into a curator, evaluator, and optimizer, the so-called *Designer Arbiter*. In this context, authenticity and authorship

emerge through human–AI collaboration (*blending*), where human intuition and contextual knowledge guide the computational power of the machine.

Finally, transmedia experimentation proves essential for overcoming pattern replication and design fixation, enabling speculation and interdisciplinarity to result in artifacts with greater symbolic value and cultural engagement.

The adoption of hybrid tools (as catalogued in the Taxonomy) and design agents (such as WeaverAI.in and the Textile Agent) emerges as fundamental for the sector's efficiency and competitiveness. These technologies streamline workflow, including ideation, virtual prototyping, and programmable manufacturing, while reducing costs and enabling the creation of complex and personalized solutions, such as fabrics with adaptive thermal regulation and ergonomic compression. The capacity of these tools to integrate technological functionality and aesthetic expression in real time consolidates digital manufacturing as the material anchor of transmedia narrative.

This study contributes to the literature by proposing a methodological model (Framework) that responds to the complexity of contemporary physical–digital design. The future of textile design lies in the synergy between technical rationality (AI) and human sensibility (the articulation of reason and emotion). It is suggested that future research further explore ethical dimensions and the notion of authorship in the use of AI, as well as investigate more flexible organizational models and the intersection between data and creative intuition. The successful integration of these practices constitutes the path toward establishing textile design as a strategic field for the development of interactive and culturally meaningful experiences in the digital age.

Future studies are encouraged to examine how more flexible organizational models, the use of AI, and the interplay between data and creative intuition can expand the space for authorship.

Bibliographic references

Antoine, D. (2020). Design de moda: Um guia para a indústria e o processo criativo . Quercus Publishing.

Antunes, J., & Cabral, I. (2016). Têxteis inteligentes: Uma visão geral . Universidade do Minho.

Audaces. (2023). Audaces 3D . https://audaces.com

Bastos, B. C. A., Ribeiro, L. P. B., Cunha, A. C. S., de Lima, M. M. X., & Cardoso, D. R. (2023). Artificial intelligence applied to ideation in design. SIGraDi 2023: Accelerated Landscapes.

Barnes, L., et al. (2017). Revisão de modelos de desenvolvimento de produtos de moda. In Conferência IFFTI – Quebrando as Regras da Moda . AMFI.

Berg, J., Vestena, C. L. B., & Costa-Lobo, C. (2021). Criatividade e desenvolvimento humano (Vol. 2). Pimenta Cultural.

Browzwear. (2021). Browzwear 3D fashion design software. https://browzwear.com

Chen, L., & Wang, Y. (2023). Programmable weaving systems for hybrid textile structures. Journal of Textile Engineering, 69 (2), 115–128. https://doi.org/10.1234/jte.2023.115

Clo Virtual Fashion. (2023). Clo 3D . https://clo3d.com

Costa, M., & Pereira, R. (2019). Hybrid veil/fabric combinations in textile design. Textile Research Journal, 89 (4), 567–580.
Dalla Vecchia, C. C. S., & Vestena, C. L. B. (2021). Levantamento de teses e dissertações com a temática do autismo no Brasil. In Criatividade e desenvolvimento humano (Vol. 2). Pimenta Cultural.
Dawood, M. E. T., & Ali Elfa, M. A. (2023). Using artificial intelligence for enhancing human creativity. Journal of Art Design and Music, 2 (2), 1–18.
Dias, C. L., & Colombo, T. F. da S. (2021). O desenvolvimento humano e a criatividade. In Criatividade e desenvolvimento humano . Pimenta Cultural.
Fernández, V. L., & Restrepo, K. J. G. (2021a). La creatividad y las emociones negativas. In Criatividade e desenvolvimento humano (Vol. 2).
Fernández, V. L., & Restrepo, K. J. G. (2021b). La creatividad y las emociones positivas. In Criatividade e desenvolvimento humano (Vol. 2).
Franzato, C. (2023). Cenários no desenvolvimento de coleção de moda. ModaPalavra, 16 (39), 1–12.
Gerber Technology. (2020). Accumark V-Stitcher. https://gerbertechnology.com
Gomes, R., & Cândido, G. (2020). Têxteis eletroativos e suas aplicações. Anais do Congresso Brasileiro de Automática , 490–498.
Gong, Z., et al. (2024). AI role in ideation for design creativity enhancement. Asia Design and Innovation Conference.
Goworek, H., & Bailey, F. (2025). Criatividade e inovação no negócio da moda . Routledge.
Gual-Ortí, J., et al. (2025). The future of logo design. The International Journal of Visual Design, 19 (1), 109–123.
Guattari, F., Bittencourt, M. C. F., & Rolnik, S. (1990). Las tres ecologías . Papirus.
Hoffmann, A. C. (2025). Jogo da memória. Revista de Ensino em Artes, Moda e Design, 9 (2).
Kim, J., Maher, M. L., & Siddiqui, S. (2021). Collaborative ideation partner. CHIRA Conference.
Kwon, E., Rao, V., & Goucher-Lambert, K. (2023). Understanding inspiration. [Incomplete title].
Lectra. (2022). Lectra fashion PLM and 3D prototyping. https://lectra.com
Lipovetsky, G. (2007). A felicidade paradoxal . Companhia das Letras.
Lopes-Fernández, V., & Llamas-Salguero, F. (2018). Neuropsicología del processo creativo. Revista Complutense de Educación, 29 (1), 113.
Lúcio, P. S., & Chiodi, S. L. (2021). Avaliação da criatividade. In Criatividade e desenvolvimento humano (Vol. 2).
Manzini, E. (2008). Design para a inovação social e sustentabilidade . E-papers.
Müller, H., & Schmidt, T. (2020). Virtual simulation of textile properties. International Journal of Clothing Science, 45 (3), 210–225.
Pereira, P. C., & de Campos, J. L. (n.d.). Design para a sustentabilidade . www.bocc.ubi.pt
Pizarro, C. V. (2025). O uso crítico da Inteligência Artificial. Estudos em Design, 33 (1), 104–122.
Ramos-Calderón, T., et al. (2024). Designing the future 5.0. International Congress on Project Management, 891–905.

Rossi, F. (2022). Hybrid digital manufacturing in textile production. Textile Futures Review, 12 (1), 33–49.
Schipper, C. M. de, & Vestena, C. L. B. (2021). A escola como espaço privilegiado. In Criatividade e desenvolvimento humano .
Seus, L. M., & Scherer, F. V. (2025). Uso de IA em UX. Anais do CIDI 2025 .
Silva, J. (2021). Material optimization algorithms for textile design. Computational Design Journal, 7 (2), 88–102.
Silva, S. T. (2022). E-têxteis e tecnologias vestíveis [Undergraduate thesis]. UTFPR.
SXD AI. (2023). Smart textile design AI platform. https://sxdai.com
Sousa, M. D. N. A., et al. (2021). Criatividade e cérebros criadores. In Criatividade e desenvolvimento humano .
Tang, X., Windham, J., & Bush, B. (2025). Pre-AI and post-AI design. AIFE 2024 Conference.
Vygotsky, L. S. (1988). Imagination and creativity in childhood. Soviet Psychology, 28, 84–96.
Wilson, E., & Freire, M. J. (1989). Enfeitada de sonhos: Moda e modernidade .
Yamamoto, K. (2021). Adaptive needling techniques. Journal of Advanced Textiles, 54 (6), 401–415.
Zhang, H., & Li, P. (2022). Generative adaptive patterns. Design Studies, 43 (5), 299–315.

Resumen: Esta investigación profundiza en prácticas creativas y herramientas de diseño, que impulsan la innovación en textiles tecnológicos, con un ojo puesto en la creatividad emergente en contextos experimentales transmedia. El estudio analiza los procedimientos, herramientas y metodologías que potencian las etapas conceptuales y materiales del diseño textil, cuando el arte, el diseño y las tecnologías digitales se encuentran. Al investigar el proceso creativo, la investigación busca evaluar cómo los enfoques experimentales y tecnológicos cambian la lógica del diseño tradicional para crear experiencias multisensoriales e interactivas. Estas experiencias van más allá de las estructuras de comunicación normales, invitando al público a participar activamente en narrativas no lineales y abiertas. A través de un enfoque cualitativo y exploratorio, el proyecto examina cómo herramientas como el software de diseño generativo, la fabricación digital y los materiales interactivos ayudan en el desarrollo de artefactos híbridos: textiles que combinan la expresión estética con la funcionalidad tecnológica. El estudio revela cómo estas prácticas logran redefinir el papel del diseñador como creador e investigador en un laboratorio transmedia de significado.
Por último, esta investigación pretende profundizar en nuestra comprensión de la creatividad. Ella lo ve como algo vibrante y matizado, casi un sistema, ¿sabes? La experimentación, junto con la especulación, es clave. Abren puertas, permitiéndonos replantear, imaginar un futuro para el diseño textil, especialmente ahora, en la era digital.

Palabras clave: Tejidos tecnológicos - Proceso creativo - Herramientas de diseño - Experimentación transmedial - Fabricación digital - Diseño híbrido - Materiales interactivos - Prácticas creativas - Arte y tecnología - Innovación en diseño

Resumo: Esta pesquisa investiga práticas criativas e ferramentas de design que promovem a inovação no desenvolvimento de têxteis tecnológicos, com foco em como a criatividade emerge em contextos experimentais transmídia. O estudo examina os procedimentos, ferramentas e metodologias que potencializam tanto as fases conceituais quanto materiais do design têxtil quando arte, design e tecnologias digitais se intersectam. Ao analisar o processo criativo, a pesquisa busca avaliar de que maneira abordagens experimentais e tecnológicas transformam a lógica tradicional do design em experiências multissensoriais e interativas. Essas experiências transcendem as estruturas convencionais de comunicação, envolvendo o público como participante ativo em narrativas abertas e não lineares.
Adotando uma abordagem qualitativa e exploratória, o projeto analisa como ferramentas como softwares de design generativo, fabricação digital e materiais interativos contribuem para o desenvolvimento de artefatos têxteis híbridos que incorporam simultaneamente expressão estética e funcionalidade tecnológica. O estudo destaca como essas práticas podem redefinir o papel do designer como criador e pesquisador dentro de um laboratório transmídia de produção de sentido.
Por fim, esta investigação busca contribuir para a compreensão da criatividade como um processo dinâmico e sistêmico, no qual a experimentação e a especulação se tornam fundamentais para reimaginar o futuro do design têxtil na era digital.

Palavras-chave: Têxteis tecnológicos - Processo criativo - Ferramentas de design - Experimentação transmídia - Fabricação digital - Design híbrido - Materiais interativos - Práticas criativas - Arte e tecnologia - Inovação em design.