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Designing the Sixth Sense: Wearable Technology and the Role of Prototyping in Fashion Tech Higher Education

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Abstract

The study investigates the design of smart jewelry, focusing on the materialization of the so-called "sixth sense" through a university workshop. The aim was to examine how in higher education designers can develop new interactions between body, object and environment by exploiting speculative tools and advanced design methods. The results show a prevalence of solutions oriented toward health and interpersonal connection, with movement and color as the main modes of output. Methodologically, storyboards, physical models, digital renderings and videos proved to be key tools to compensate for the lack of technological prototyping. The conclusions emphasize the potential of wearable technologies to broaden the sensory experience and open up new design perspectives in fashion tech.

Keywords: *Fashion-tech, jewelry design, speculative prototyping, digital technology, wearable interaction, human-centered design.*

1. From body to behavior

In recent years, academic research in the field of Fashion Tech has placed increasing emphasis on training professionals who can manage design complexity by developing creative skills capable of integrating and enhancing technological innovation (EDU4FashionTech Benchmarking Report (Colombi & Tenuta, 2020) and "FTAlliance. Weaving Universities and Companies to Co-create Fashion-Tech Future Talents," a three-year (2020-2022) Knowledge Alliance Project co-founded by the Erasmus+ Program of the European Union (GA 612662-EPP-1-2019-1-IT-EPPKA2-KA). Designing products with integrated technology is an interdisciplinary field, characterized by the convergence of physical, symbolic, emotional, experiential and interactive dimensions. This complexity requires a critical review of the design processes and tools used in design so that they can adequately support the creation of hybrid and innovative solutions. The present study examines a university workshop focused on the concept of jewelry behavior, defined as the capacity of jewelry to exhibit dynamic responsive

actions through the integration of technology. The study thematically addressed the materialization of an intangible human sensory experience, exploring how technological enhancement enables jewelry to embody perceptual and affective dimensions. The scholarly literature highlights the growing interest in integrating the physical and digital dimensions of experience, particularly in contexts where interaction with the body plays a central role (Rossato, 2024; Tenuta & Rossato, 2023; Cappellieri et al, 2022; Testa, 2019; Mistry et al, 2009). This approach brings design thinking back to corporeality and the tangible transposition of intangible stimuli. In this perspective, the interaction between subject and object gains relevance as a reciprocal and meaning-making process. As described in the fourth category of embodiment by Van Rompay and Ludden (2015), the object actively shapes the user experience, fostering engagement through its affordances and responses. The main objective of the workshop was to test, within the academic realm of higher education, the possibility for designers to design the behavior of jewelry by exploiting digital technologies to generate new modes of interaction between object and user. The centrality of the materialization of experience emerged as a key element of the design process, with digital technology used not only as a technical tool, but as a means to activate new forms of relationship between body and object. The case study focuses on the concept of the sixth sense and how wearable digital technologies can amplify human sensory perception (Baker and Boddington, 2022), transforming intangible inputs into tangible signals and, as a result, fostering new modes of interaction between users, their bodies and their surroundings.

2. Case Study: “Sixth Sense (SS)” Workshop

2.1. Significance and Objectives

The Sixth Sense (SS) workshop was conducted with jewelry design students in the three-year degree program at Politecnico di Milano. The structure and method will be explained below, but it is important to first mention the meaning and objectives of the brief and related analysis. As the title itself suggests, the brief was to explore the concept of sixth sense through the integration of technology within the fashion product, in this case a piece of jewelry made in collaboration with an Italian fashion company. The case study thus refers to the context of wearable technologies and, in particular, smart jewelry. The intention to investigate this topic stems from some recent considerations in the literature. In particular, the EDU4FashionTech Benchmarking Report (Larsson et al, 2018) highlighted 5 possible future developments in the Fashion-Tech sector: (a) body protection and enhancement through an artificial second skin; (b) culture-based wearables: art, technology and innovation; (c) hyper-body: connection between senses and materials; (d) fashion that takes care of the person; (e) mixed real/virtual environments. The (c) scenario proposed an exploration of human senses and materiality, particularly for sight, hearing and touch, where technology was configured as a support for

exploring, controlling and empowering the human body. Crossing the boundary of bodily sensory perception, the decision to introduce the sixth sense as the first investigative boundary in the project brief was intended to suggest future considerations on the Hyper-body and Extra-Humans scenarios proposed in the report (Colombi & Tenuta, 2020). In this perspective, digital technology embedded in fashion objects becomes the means to materialize additional intangible information. What if a smart piece of jewelry worn on the body acts as an extension of our sensory perception and becomes, materially, our sixth sense? The sixth sense is defined here as "a power of perception similar to, but not belonging to, the five senses: a distinct intuitive ability". There is no scientific evidence for the existence of this phenomenon, apart from alleged anecdotal evidence that by its nature has no scientific credibility or statistical significance, nor a proven physical correspondence between the sixth sense and the human body. Rather, it can be defined as a supposed, intangible intuition involving the body itself. Far from trying to prove its existence, the sixth sense is here regarded as an intangible subject related to the body to be materialized. Between empowering the body and reconnecting with our embodied experience, the sixth sense is used as a narrative concept to define the design limits of the brief (Rossato, 2024). The analysis pursued two main objectives: thematic and methodological. The first aimed to explore how students interpreted the concept of the sixth sense and its materialization through body-related smart jewelry. This also included examining the emerging meanings related to the designed objects, with particular attention to the perceived level of embodiment. The second, the methodological objective, aimed to evaluate the effectiveness of the design activity within an academic context, highlighting the pedagogical opportunities and limitations encountered throughout the process.

2.2. Structure and method

The workshop took place over 13 days in October 2021. The activity involved: 40 students (including 4 international students) enrolled in the third year of the three-year degree program in Fashion Design at Politecnico di Milano; 1 Italian fashion company; 1 professor of jewelry design; 1 tutor (PhD student in design supporting the activity). The design activity was carried out individually by all participants. Figure 1 shows the overview of the structure of the design and review process initially set up.

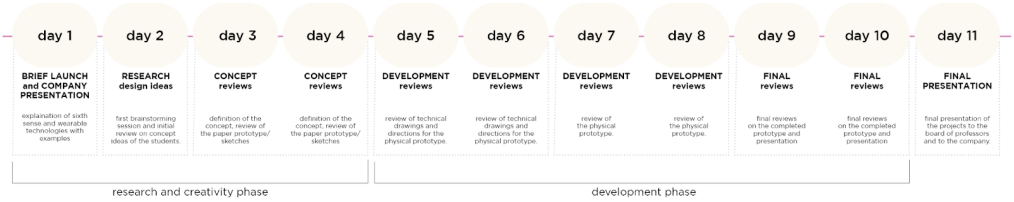

Figure 1. Overview of the workshop structure and the design process followed for the creation of the smart jewel (created by the authors).

The workshop was conducted mainly through a learning-by-doing approach, with constant monitoring and revisions by the professor and the course tutor. The analysis was conducted through this continuous observation of the design process, enriched by informal exchanges within the course and subsequent analysis of the projects developed. The initial brief was presented along with the company's presentation. In this case, it was important to associate experimentation on the theme described with a product created for the company, to give more credibility and feasibility to the design outputs. More time was spent on the development phase to create a physical prototype to show how the technology works. Integration of the actual technology was not required, as the workshop was mainly devoted to the design idea, i.e., concept development. However, the design had to be feasible and not refer to a non-industrial or purely artistic approach. The brief request and the proposed experimentation are schematized in the framework in Figure 2, used to analyze the project outputs. Starting from an intangible input, internal or external to the body, the jewelry was to act as a perceptual translator (i.e., the sixth sense) to materialize the signal (output).

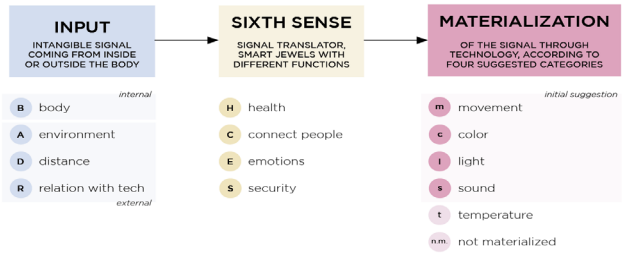

Figure 2. Input-sixth sense-materialization system, with related interpretation of the design outputs. (created by the authors).

The output would relate to the user's own body, the surrounding environment, or other bodies. The initial constraints were related to the perceptual translator value of the sixth sense, i.e., the possibility of the jewelry detecting an input before the user's body or in relation to information of which the body itself was unaware. There were no initial constraints with respect to the type of input or sixth sense, and certain types of materialization were suggested to facilitate brainstorming on the output of the technology, i.e. light, motion, color, and sound. The types of interaction that wearable technologies can introduce were suggested through existing examples in the clothing and accessory industry. To facilitate understanding of the topic beyond the field of design, we briefly present some examples that were shown to the students: the *Spider Dress* by Anouk Wipprecht moves according to respiratory and motion data collected from the wearer's body; *Neclumi*, a necklace that projects customizable light graphics onto the neck of the wearer; *Bodyscape* by Behnaz Farahi, an interactive fashion object that lights up by analyzing and mirroring the body's movements; *ShiftWear*, which integrates a digital display into fabric to create sneakers that can change appearance and be customizable via smartphone;

Caress of the Gaze, a 3D-printed interactive garment capable of detecting another person's gaze and reacting through movement.

3. Results and analysis

3.1. Thematic considerations

The design workshop resulted in 40 smart jewelry design outputs on the theme of the sixth sense. The analysis focused on three key dimensions: the relationship between input, sixth sense, and materialization; the degree of embodiment in the design outputs; the modes of interaction among the body, other people, and the environment.

3.1.1. Analysis of the relationship between input, sixth sense, and materialization

The input–sixth sense–materialization system was analyzed using macro-categories to highlight the main interpretative patterns. Inputs were classified into four types: Body (B), Environment (A), Distance (D), and Relation to technology (R), further grouped into internal (B; 24 outputs) and external stimuli (A, D, R; 16 outputs). Four primary interpretations of the sixth sense were identified: Health (H), Connecting People (C), Emotions (E), and Safety (S). Materialization modes included movement (m), color (c), light (l), and sound (s), with an additional category, temperature (t), emerging from the analysis. Three projects did not involve physical materialization (Digitized). Figure 3 provides a schematic synthesis of these findings.

	category	description	n° of outputs
INPUT	B body *internal*	stimulus comes directly from the body.	24
	A environment *external*	stimulus comes from the surroundings.	7
	D distance *external*	stimulus tracks the position of objects relative to each other.	8
	R relation with tech *external*	stimulus comes from interaction with technology.	1
SIXTH SENSE	H health	protecting the body (e.g., detecting harmful environmental agents, monitoring a physical condition, rebalancing well-being)	18
	C connect people	connecting individuals through community, identity, and relationships.	9
	E emotions	expressing or experiencing emotions through technology to interact with others or to experience a personal feeling in a tangible way.	9
	S security	protection and signaling, such as to warn of surrounding dangers or facilitate a call for help.	4
MATERIAL-IZATION	m movement	physical movement of the object in response to input.	18
	c color	change in color to express emotions or physical states.	10
	l light	use of light to convey sensory information.	6
	s sound	sound responses to stimuli (e.g., psychological discomfort).	2
	t temperature	change in temperature as materialization.	1
	n.m. not materialized	the sixth sense is not materialized physically, but digitized (e.g.,design of an AI digital assistant).	3

initial suggestion

Figure 3. Findings of the input–sixth sense–materialization system's analysis (created by the authors).

3.1.2. Analysis of the degree of embodiment

Although embodiment was not explicitly required in the brief, the body-centered nature of the topic naturally led to embodied outputs. Based on definitions from Van Rompay and Ludden (2015) and Merriam-Webster, embodiment was interpreted in two ways: Embody (Incorporate) → when the design becomes part of the body or acts as an extension of it; Personify (Personify) → when the design represents human or animal forms. The analysis further identified two main categories of jewelry behavior: "Technology to Human" (18 designs) where technology is humanized, taking on anthropomorphic or behavioral characteristics similar to humans or animals; and "Human to Technology" (9 designs) where human interaction mimics digital behaviors (e.g., light notifications or materialization of social media feedback). Thirteen projects showed no clear embodiment, focusing instead on environmental stimuli, without behavioral references (e.g., perception of ultrasound or reaction to environmental sounds).

3.1.3. Interaction between body, environment and other people

The analysis of interaction considered four main modes. "Body-to-body" (14 designs): the jewel interacts solely with the wearer's body, through either conscious (5) or unconscious (9) input, encouraging self-awareness. "From body to others" (8): internal bodily signal are externalized, promoting connection and interpersonal communication. "Environment to Body" (12): the jewelry informs the body about intangible events (e.g., air pollution or harmful UV rays) or supports community-based awareness (e.g., locating people in space or signaling their presence or absence). "From environment to others" (4): the jewel activates only in response to external signals, functioning within a community without direct bodily interaction.

3.2. Pedagogical and Methodological considerations

Beyond the thematic outcomes, the workshop revealed key insights into the pedagogical potential of prototyping without technology. Participants had to imagine scenarios, products, and experiences through alternative tools that would allow for a plausible representation of their ideas. In line with Ferraris' (2023) framework on the functions of the prototype in design education, students explored speculative scenarios using a combination of analog and digital tools. The storyboard, understood as a sequential graphical representation, played a key role in outlining the user experience at the design stage. This tool was employed to visualize the flow of interaction with the product, map the user journey, and identify potential critical issues, thus facilitating an informed, experience-centered approach. Specifically, the storyboard supported three main phases: Envision and speculate, i.e. defining the initial idea and interaction possibilities; Create and design, i.e. structuring the design through visual sequences; Comprehend, i.e. identification of user needs and potential improvements to the experience. The storyboard was a valuable tool, especially in the initial phase of the design process, transforming participants from students into narrative creators. Integrated technology needs the management

of both the aesthetic dimensions of design and the user experience, positioning participants as hybrid figures. Furthermore, the creation of physical models was critical in translating design ideas from the conceptual to the concrete stage. It allowed: to evaluate the development of the idea and first iterations of the design; to represent the form and wearability simulation; to evaluate the aesthetic and tactile qualities; to explore and understand the experimentation with design variations; to communicate through a visual presentation of the product. The design process included the use of 3D modeling software such as Rhinoceros, SolidWorks, and KeyShot to create detailed visualizations of the product. Digital rendering played a key role in two main areas: first, it helped to develop the design by refining and defining the formal details, and second, it was used to communicate the concept by generating realistic images that encouraged critical discussion and feedback. Additionally, video became an important communication tool, although not explicitly requested. Several students chose to produce videos to show the jewelry behavior. Video proved to be an effective medium for showcasing the behavior of the product, clarifying the dynamics of interaction, and illustrating how the object responded to external stimuli. Furthermore, the use of video facilitated feedback from others, enabling a better understanding and critical evaluation of the design. These strategies enabled students to simulate, visualize, and evaluate their ideas despite the absence of working integrated technology, providing concrete tools to explore the relationship between the body, technology, and sensory interaction.

3. Conclusions

Thematically, the investigation into the materialization of the sixth sense through smart jewelry design showed a tendency for students to focus on four main areas: health, connection between individuals, expression of emotions, and safety. The dominance of the categories health (45%) and emotions (22.5%) highlights a design orientation to interpret the sixth sense as a tool for personal protection and well-being, rather than as a means of extended interaction with the environment. In addition, the preference for movement (45%) and color (25%) as output modes suggests a strong connection with the visual and kinetic dimensions of sensory perception. On the pedagogical and methodological level, the workshop confirmed the effectiveness of the combined use of representational and prototyping tools in supporting the creative process in the absence of functioning technologies. The storyboard proved to be a useful tool in the initial stages of design, while physical models played a key role in verifying the wearability and aesthetic rendering of concepts. 40% of students also used video media as a communication tool, demonstrating a growing trend toward visual storytelling to illustrate the behavior of designed objects. The experience highlighted some limitations, most notably the lack of technical expertise, which prevented an in-depth analysis of the technological feasibility of the developed concepts. Additionally, students faced challenges in translating abstract ideas, such as the concept of the sixth sense, into tangible and practically feasible design solutions. This

limitation addresses the need to refine pedagogical tools to enhance strategies for the definition and validation of the ideas. Moreover, the study confirms the need and importance of training interdisciplinary and hybrid professional development (Larsson et al, 2018 and Colombi & Tenuta, 2020). Designers need to manage both creative and technical competencies, suggesting that future development of the research could investigates better how to seamlessly integrate creative speculative conceptualization with technological requirements.

References

Baker, C & Boddington, G. (2022) Editorial. Extended senses: embodying technology. *Intellect - Virtual Creativity, Issue Extended Senses: Embodying Technology*, 12 (1). pp. 3-8. ISSN 2397-9704 (Print), 2397-9712 doi:https://doi.org/10.1386/vcr_00057_2

Cappellieri, A., Rossato, B., Tenuta, L., & Testa, S., (2022). Digital Filters: A New Way to E-Wear Jewellery. In Ahram, T., & Taiar, R., (Eds.), *Human Interaction, Emerging Technologies and Future Systems V* (pp. 837-843). Springer https://doi.org/10.1007/978-3-030-85540-6_106

Colombi, C., & Tenuta, L. (2020). *Education for fashion-tech. Design and technology for future fashion creatives*. Nielsen Book. ISBN 978-1-906908-64-5.

Ferraris, S. D. (Ed.). (2023). *The Role of Prototypes in Design Research: Overview and Case Studies*. SpringerBriefs in Applied Sciences and Technology, PoliMI SpringerBriefs. Springer

Larsson, J., Vellesalu, A., Cappellieri, A., Colombi, C., Tenuta, L., Teunissen, J., Kapsali, V., Miller, G., Berge, C., Freundorfer, B., Henchoz, N., van Dongen, P., & Walter, L. (s.d.). (2018) *Fashion Tech. Education and research. Benchmarking Report. Education4Fashion-Tech.*

Mistry, P., Maes, P., & Chang, L. (2009). WUW - wear Ur world: A wearable gestural interface. *CHI '09 Extended Abstracts on Human Factors in Computing Systems*, 4111–4116. https://doi.org/10.1145/1520340.1520626

Rossato, B. (2024). *Embodied Digital Fashion. Supporting the Design Practice of Future Creatives in Dematerialization* (Doctoral dissertation). Available from May 2027 from Politecnico di Milano Politesi.

Tenuta, L. & Rossato, B., (2023). Digital Jewelry and Virtual Exhibition: Interaction in the Metaverse. *Proceedings of EDULEARN23 Conference.* 3rd-5th July 2023, Palma, Mallorca, Spain. ISBN: 978-84-09-52151-7, DOI: 10.21125/edulearn.2023

Testa, S. (2019). *FashionTech. Body Equipment, Digital Technologies and Interaction*. Mantua (MN), Italy: Universitas Studiorum. ISBN 978-88-3369-057-5.

Van Rompay, T. J. L., & Ludden, G. D. S. (2015). Types of embodiment in design: The embodied foundations of meaning and affect in product design. *International Journal of Design*, 9(1), 1-11. https://www.ijdesign.org/index.php/IJDesign/article/view/1670/673